Volume 4 APRIL, 1925 Number 4

JOURNAL

OF THE

AMERICAN WELDING SOCIETY

Published Monthly by the American Welding Society
33 West Thirty-ninth Street, New York

American Welding Society

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JOURNAL

OF THE

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33 West Thirty-ninth Street, New York.

Subscription $10.00 per year to United States. $11.00 to Canada. Libraries $5.00.
Back numbers, per copy; Members, $0.50; Non members, $1.00.

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AMERICAN WELDING SOCIETY
ESTABLISHED 1919
JOURNAL

Volume 4 April, 1925 Number 4

AMERICAN BUREAU OF WELDING

OUTSTANDING FEATURES OF PROGRESS

ANNUAL REPORT

General:

From an organizational standpoint the principal progress that the Bureau has made has been in getting a better notion of the kind of work that ought to be of best service to the welding industry. When the Bureau was first organized several years ago, the welding industry was in a more or less chaotic state in that the reasons why failures or successes were obtained by the use of the several fusion welding processes were not understood.

It was natural therefore that the Bureau should appoint several research sub-committees to deal with the fundamentals of the different fusion welding processes and also sub-committees on specific problems brought to its attention by the industry.

Excellent work was done by nearly all of these sub-committees and reports were produced which have been in demand all over the world. At the same time an information service has been developed to answer specific inquiries or to indicate sources of information. This service has been appreciated and widely used by engineers, societies and commercial firms.

Having successfully solved some of the smaller problems presented to it, it was also natural that the Bureau should contemplate embarking upon still greater problems. In consequence we may look forward to the next year or two to the Bureau having fewer research projects but of greater importance.

Publications:

The medium of disseminating information by the Bureau continues to be through the Journal of the American Welding Society. In one instance, however, namely Welded Rail Joints, this medium is also the publication of the American Electric Railway Association.

Administration:

The American Bureau of Welding acts as the Welding Research Department of the American Welding Society and of the Division of Engineering, National Research Council. It also has among its membership representatives from some twenty scientific and technical organizations interested in welding, among which is included Engineering Foundation. The Bureau operates under its own by-laws which are subject to both the by-laws of the American Welding Society and of the Division of Engineering, National Research Council. The director is C. A. Adams and the secretary, W. Spraragen. Office facilities are furnished by the American Welding Society, although in one or two instances where committees have sufficient funds the Society has been reimbursed for an appropriate portion of the expense.

Completed Projects:

During the past year four sub-committees that had completed their work were officially discharged. These are:

"Standard Tests for Welds," F. M. Farmer, chairman. The final report was published as Bulletin No. 1, American Welding Society.

Welding of Storage Tanks," J. C. Lincoln, chairman. Published reports: "Specifications for Welding of Storage Tanks by the Electric Arc Process," December, 1922, issue of Journal of American Welding Society; "Specifications for Welding of Storage Tanks by the Gas Process," June, 1923, issue of the Journal of the American Welding Society.

"Training of Operators," J. C. Wright, chairman. Published reports: "Training of Oxy-Acetylene Welders," Bulletin No. 4; "Training of Electric Welders," Bulletin No. 7, of the American Welding Society.

Welding of Pressure Vessels, H. L. Whittemore, chairman. Published report: "Welded Pressure Vessels," Bulletin No. 5, American Welding Society.

Progress of Active Projects:

The outstanding activity of the Bureau during the past year has been its work in connection with the Welded Rail Joint Committee. This committee is working in close cooperation with the American Electric Railway Association and has a membership of about sixty individuals including way engineers of the several larger street railway companies, representatives of manufacturers of welded joints and welding equipment, welding experts, executives and testing experts. Two progress reports have been published and the third will be printed very shortly. The first phase of the investigational program to "determine the present state of the art" in making welded rail joints is nearly finished. Way engineers have learned valuable lessons as the result of these tests. Moreover, the committee has been able to draw up a program for the second phase of its activities which has for its object the improvement of each type of joint. Efforts have been concentrated for the present on the seam welded joint, and it is expected that within the next month or two the test specimens will be made up which will indicate the effect of various variables on the quality of this type of joint. Although the welded rail joint problem is the most difficult yet undertaken by the American Bureau of Welding, nevertheless the Bureau is hopeful that success will attend its efforts in this direction. Possibilities are enormous, as an increase of 25 per cent in the life of the joint will result in an annual saving to the street railways of the country of over $15,000,000.

The Electric Arc Welding Committee has completed a series of investigations to note the effect of various fundamentals in the electric arc welding of mild steel. This investigation was started during the war but was dropped at the close of the war because of the lack of funds. Through the courtesy of the General Electric Co. and the Electrical Testing Laboratories the specimens were carefully preserved and are now being tested at the laboratories of Union College. An investigation has also been started on the welding of nonferrous metals and samples have been made up by several different companies to determine the "present state of the art."

The Gas Welding and Resistance Welding Committees of the Bureau published during the past year two critical reviews of existing information, namely "Spot Welding," published in the September, 1924, issue of the Journal of the American Welding Society, and "Gas Welding of Manganese Steel," published in the May, 1824, issue of the Journal.

Contemplated Activities During the Coming Year:

The officers of the Bureau have spent a good deal of time in planning a comprehensive investigation looking toward the extension of the use of welding in the fabrication of large structures, such as bridges, cranes, buildings, etc. Preliminary study indicates that welding has enormous possibilities both as regards to economy and better product.

What is really needed is a $200,000 investigation to secure the fundamental data needed by the designer, draftsman, engineer and legislator. In this enormous task the Bureau hopes at the proper time to interest the National Research Council. A great deal of preliminary work must be done, however, in securing the necessary cooperation of structural engineers, steel companies and fabricators. As an initial step, the Bureau assisted the American Welding Society in preparing papers for its fall meeting held in Cleveland in October, 1924, on the general subject of "Welding as a Means of Fabricating Large Structures." These papers attracted wide interest and have been commented upon editorially by the technical press. Several other preparatory steps of this nature are now under way and it is hoped by the end of this year that the Bureau will be in a position to request the National Research Council to sponsor this project.

C. A. ADAMS,
Director, American Bureau of Welding.

JOINT WELDING MEETING

A joint welding meeting was held in Bethlehem, Pa., on April 3, under the auspices of the Bethlehem Steel Company, American Society for Heat Treating and Lehigh Valley Engineers.

Six companies participated in welding and cutting demonstrations from 2.30 to 5 p. m. The Air Reduction

Sales Company demonstrated their radiagraph by splitting a billet 8 in. x 8½ in. x 20½ in. long in 4 minutes, 40 seconds. The cutting was smooth and satisfactory in every respect. Circles were cut from slabs varying from ¼ in. to 1⅜ in. in thickness. The Oxweld Company demonstrated the use of manifolds, regulators, straight line cutting machines, welding and cutting torches, etc. The Metal & Thermit Corporation made pipe welds and a heavy weld on 6 in. x 6 in. section. The General Electric Company operated an electric arc machine consisting of a lathe with welding machine attached. This demonstrated the practicability of building up worn bearings on armature and other shafts. The Westinghouse Electric & Mfg. Co. and the H. Kleinhans Company made arc welds on steel plates. There followed a film by the Metal & Thermit Corp. Mr. Van Alstyne of the Air Reduction Sales Co. made some liquid oxygen experiments which was followed by the showing of the film "Oxygen—the Wonder Worker" by Mr. F. E. Rogers of the same company.

A buffet supper was served and at 7.30 the evening program was started. Mr. A. G. Bissell of the Westinghouse Electric & Mfg. Co. gave an illustrated talk on "Metallurgy of Electric Arc Welds." Mr. J. J. Crowe of the Air Reduction Sales Company presented an illustrated paper on "Oxygen Purity." He was followed by Mr. D. H. Deyoe of the General Electric Company, who talked about fifteen minutes on arc welding. Mr. E. E. Thum of the Union Carbide & Carbon Corp. spoke on the "Heat Effects of Cutting" and showed interesting microphotographs comparing the relative heating effects of the friction saw as compared with oxyacetylene cutting. Mr. Thum showed that the deterioration of the metal adjacent to the cut is much greater with the saw than with the torch. Mr. J. H. Deppeler of the Metal & Thermit Corp. showed lantern slides of heavy thermit welds. The last speaker was Mr. S. W. Mann of the H. Kleinhans Co. His topic was "Precision Welding with Electric Arc," and he demonstrated how he proceeds in making welds in long shafts and other parts to insure bringing the parts back to the original position when finished.

Annual Report Meetings and Papers Committee, American Welding Society

Functions

During the last several years the functions of the Meetings and Papers Committee of the American Welding Society have been:

1. To arrange the programs for the fall and annual meetings of the national society.

2. To assist the local sections of the American Welding Society in securing suitable speakers for their meetings.

3. Determination of policy in connection with editorial, technical and advertising material included in the Journal of the Society.

Fall Meeting

The fall meeting of the society was held in Cleveland during the latter part of October. There were the usual committee meetings, dinner, inspection trips and technical session. There has been established an unwritten policy in the minds of the members of the Meetings and Papers Committee that the technical session of the fall meeting of the society should further some important project of the society. On this occasion, the object was to open the campaign of the American Bureau of Welding in initiating a $200,000 investigation in the fields of application of welding to structural work. Important representatves of the structural steel interests were present at this meeting, and the papers were commented on editorially by the technical press interested in iron and steel and their fabrication.

Annual Meeting

The program for the coming annual meeting has been reported in the Journal in previous issues. The technical session is to be devoted to a symposium of two subjects of vital interest to the welding industry. On the satisfactory solution of these two subjects depend further extensions of the use of welding. The two subjects in question are:

1. Methods to be employed by various industries in inspecting their welding work.

2. Methods employed by various industries in checking up and testing

the skill of their welding operators.

Members who have any information on either or both of these subjects are urged to send in their discussions to the editor as soon as possible, as the balance of these contributions will be printed in the June issue of the Journal.

Exhibits

A novel feature has been proposed in connection with the fall and annual meetings, namely, to hold exhibits of welding apparatus and welded products. The merits and demerits of this feature have been discussed at the meetings of the committee, but no definite action was taken, as it was felt that the decision should rest in the hands of the executive committee.

Local Section Programs

One of the most important accomplishments of the committee has been the assistance rendered to local sections in securing suitable speakers for their meetings. The committee hopes to continue this assistance as long as it proves necessary and takes this opportunity of thanking the various representatives of the welding industry and particularly the manufacturers who cooperated by presenting papers, moving pictures and demonstrations whenever called upon.

Journal

The Journal of the American Welding Society continues to be a financial success. On the other hand, while the advertising has increased to some extent, nevertheless, the cost of publication has also increased, leaving a net balance only slightly larger for 1924 than for 1923. With the increased number of members and the wider circulation of the Journal we hope that our advertisers will find their patronage profitable and at the same time attract new advertising. Much can be done by the membership committee in this connection. The more members secured the greater the circulation and the greater the advertising inducements. This is very clearly indicated by the publication of the Directory of the American Welding Society as the August issue of the Journal. In this issue, the number of printed copies was increased to 4000, which attracted several hundred dollars of additional advertising.

No serious criticism has been received in the way the Journal has been handled. There is considerable room for improvement, principally through the publication of discussion of papers. It apparently is not recognized by the membership at large that the meetings and papers committee would welcome discussion of any paper printed in the Journal and such discussions would be printed in the next issue of the Journal following the date of its receipt. The summation of the printed pages of the Journal are as follows:

Year 1924

Editorial	96 pages
Technical papers.....	494 pages
Advertising and circular matter	222 pages
Total	812 pages

In conclusion your committee wishes to state that it welcomes at any time the advice and assistance of any member of the American Welding Society.

Respectfully submitted

MEETINGS AND PAPERS COMMITTEE,
K. H. CONDIT, Chairman.

List of New Members for the Months of January, February and March

BOSTON

Chas. H. Haddrell (C), Electrical Engineer, General Electrical Co., (res.) 10 Hampden St., Swampscott, Mass.

V. M. Goode (D), Electric & Acetylene Welder, Submarine Base, Box 48, New London, Conn.

CHICAGO

H. S. Card (B), Managing Editor, The Welding Engineer, 608 So. Dearborn St., Chicago, Ill.

A. W. Holmes (B), Chemist & Metallurgist, Indiana Steel & Wire Co., Muncie, Ind.

Alfred W. Young (C), Acetylene Welder, 811 Trimble Ave., Kalamazoo, Mich.

Jimmie Ingels (D), Electric & Acetylene Welder, (res.) 1806 So. 5th St., Springfield, Ill.

CLEVELAND

Carl F. King (C), Sales Engineer, General Electric Co., 632 Vive St., Cincinnati, Ohio.

Michael A. Daly (D), Electric Welder, Hydraulic Pressed Steel Co., 2987 East 57th St., Cleveland, Ohio.

Mike Mylone (D), Electric Welder and Cutter, Rudd Machine Co., (res.)

1606 Marshall St., Benwood, W. Va.

G. E. Phelps (D), Supervising Welder, Air Reduction Sales Co., (res.) Olmstead Hotel, Cleveland, Ohio.

DETROIT

C. M. Bloodgood (B), Sales Manager, Air Reduction Sales Co., 7991 Hartwick St., Detroit, Mich.

G. H. Calender (B), Manager, Air Reduction Sales Co., 7991 Hartwick St., Detroit, Mich.

C. E. Phillips (B), Manager, Purox Co., 620 E. Hancock St., Detroit, Mich.

C. Rex Richards (B), Manager, Welding Engineers, 4489 14th St., Detroit, Mich.

P. D. Wade (B), District Manager, Oxweld Aceytlene Co., 338 John R., Detroit, Mich.

B. M. Wright (B), Manager, Pioneer Boiler Works, (res.) 105 Bard St., Port Huron, Mich.

C. Centus (C), President, Titus Welding Co., 3141 Cass Ave., Detroit, Mich.

Spencer B. Field (C), District Representative, Burke Electric Co., 1904 Dime Bank Bldg., Detroit, Mich.

S. M. Harvey (C), President, Electric Welding Machine Co., 2000 East Larned St., Detroit, Mich.

Robt. A. Houston (C), Secretary and Treasurer, Titus Welding Co., 3141 Cass Ave., Detroit, Mich.

J. B. Manor (C), Sales Manager, Weldit Acetylene Co. 638 Bagley St., Detroit, Mich.

Wm. E. Massey (C), Salesman, Weldit Acetylene Co., 638 Bagley St., Detroit, Mich.

R. G. Richards (C), Salesman, Lincoln Electric Co., 519 Free Press Bldg., Detroit, Mich.

Otis L. Smith (C), President, Weldit Acetylene Co., 638 Bagley St., Detroit, Mich.

R. J. Krebs (D), Electric Welder and Manager, Reliable Electric Boiler Welders, 908 McKinley Ave., Toledo, Ohio.

KANSAS CITY

O. C. Smith (B), Vice-President, Kansas City Structural Steel Co., 21st & Metropolitan Ave., Kansas City, Kansas.

Robt. H. Miller (C), Commercial Engineer, General Electric Co., 510 Dwight Bldg., Kansas City, Mo.

NEW YORK

James H. Edwards (B), Assisant Chief Engineer, American Bridge Co., 71 Broadway, New York City.

Wm. Schenstrom (B), Welding Engineer, Electric Welding Co. of America, (res.) Crescent Athletic Club, Brooklyn, N. Y.

Wm. J. Dietzel (C), Electric Welder, Standard Welding Corp., (res.) 21 Grant Ave., Jersey City, N. J.

T. C. Fetherston (C), Publicity Dept., The Linde Air Products Co., 30 East 42nd St., New York City.

E. L. Norris (C), Electric Welder, Lidgerwood Mfg. Co., (res.), 483 17th St., Brooklyn, N. Y.

John Dophal (D), Welder, Electric Welding Co. of America, 744 Court St., Brooklyn, N. Y.

Wm. MacPherson (D), Welder and Cutter, Buckingham Steel Co., (res.) 446 44th St., Brooklyn, N. Y.

Roger O. Ackerman (C), Electrical Engineer, Local Sales Office, General Electric Co., Schenectady, N. Y.

C. J. Cole (C), General Foreman of Boiler and Blacksmith Shops, General Electric Co., (res.) Norway Place, Pittsfield, Mass.

C. T. Cole (C), Foreman, General Electric Co., (res.) 47 Mader St., Schenectady, N. Y.

Frank A. Haughton (C), Consulting Mechanical Engineer, General Electric Co., (res.) 3 Avon Road, Schenectady, N. Y.

J. C. Horstman, (C), Consulting and Engineering, General Electric Co., Room 242, Bldg. 4, Schenectady, N. Y.

L. H. Inman (C), Foreman Welder, General Electric Co., (res.) 1725 Union St., Schenectady, N. Y.

Carl L. Ipsen (C), Designing Engineer, General Electric Co., (res.) 11 Lakewood Ave., Schenectady, N. Y.

F. M. Jefts (C), Engineer, General Electric Co., Industrial Control Dept., Schenectady, N. Y.

W. V. Lewis (C), Foreman, Structural Steel Dept., General Electric Co., Bldg., 70 D, Schenectady, N. Y.

J. H. Martin (C) General Foreman in charge of tank welding, General Electric Co., (res.) 124 Newell St., Pittsfield, Mass.

C. D. Mills (C), General Foreman, General Electric Co., (res.) 134 Woodleigh Ave., Pittsfield, Mass.

Robt. Palmer (C), Mech. and Elec. Supt. of Research Lab., General Electric Co., Bldg. 5, Room 205, Schenectady, N. Y.

S. Pidgeon (C), Welding Instructor, General Electric Co., (res.) 110 Robbins Ave., Pittsfield, Mass.

L. A. Sheldon (C), Engineer, General Electric Co., Room 441, Bldg 2, Schenectady, N. Y.

C. Steenstrup (C), Supervisor Mechanical Research, General Electric Co., Schenectady, N. Y.

Andrew Vogel (C), Engineer, Plant Engineering Dept., General Electric Co., Schenectady, N. Y.

J. Murray Weed (C), Member of Industrial Engr. Dept., General Electric Co., (res.) 17 Engleman Ave., Scotia, N. Y.

R. A. Weinman (C), Research Engineer, General Electric Co., Research Laboratory, Schenectady, N. Y.

Alex. P. Wood (C), Designing Engineer, A. C. Eng. Dept., Bldg. 41, General Electric Co, Schenectady, N. Y.

J. E. Yorkston (C), Consulting Mechanical Engr., General Electric Co., Schenectady, N. Y.

Malcolm B. Little (D), Student of Arc Welding, General Electric Co., (res.) 1211 Broadway, Schenectady, N. Y.

M. Powell (D), Welder, General Electric Co., (res.) R.F.D. No. 8, Scotia, N. Y.

WESTERN NEW YORK

John Cattanach (C). Superintendent, Genesee Bridge Co., Box 42, Rochester, N. Y.

John Roche (D), Welder and Cutter, Lackawanna Steel Construction Corp., (res.) 109 Sumner St., Buffalo, N. Y.

PHILADELPHIA

W. H. Mohr (B), Plant Manager, Lehigh Structural Steel Co., Allentown, Pa.

T. A. Jones (C), Sales Engineer, The American Steel Engineering Co., 10 So. 18th St., Philadelphia, Pa.

Harry E. Horn (D), Supt. of Machine Shop, Coplay Cement Mfg. Co., (res.) 57 Fifth St., Coplay, Pa.

Wm. F. Missimer (D), Head Electrical Welder, Coplay Cement Mfg. Co., (res.) 335 No. 14th St., Allentown, Pa.

PITTSBURGH

J. C. Armor (D), E.E., Pittsburgh Transformer Co., West View, Pittsburgh, Pa.

SAN FRANCISCO

A. C. Waldorf (D), Welder, 1930 Barrett Ave., Richmond, Cal.

R. O. Waldeman (D), Welding Supply Jobber, Reid Avery Co., 550 Howard St.

NOT IN SECTIONS

A. H. C. Boissier (B), Purchasing Agent, Purox Co., 1135 St. Paul St., Denver, Colo.

W. Crabtree (B), Manager, Australian Oxygen & Industrial Gases, Pty., Ltd., 550 Latrobe St., Melbourne, Australia.

A. S. Turnbull (B), Sales Manager, Canadian Liquid Air Co., Ltd., Room 403, 285 Beaverhall Hill, Montreal, Canada.

E. Bachman (C), Sales Engineer General Electric Co., 1016 Continental Bank Bldg., Salt Lake City, Utah.

G. N. Barker (C), Arc Welding Specialist, General Electric Co., Portland, Ore.

E. J. Bartz (C), Supt. Engine & Loco. Depts., General Electric Co., Erie, Pa.

C. E. Becker (C), Salesman, General Electric Co., 1415 Swinney Park Pl., Fort Wayne, Ind.

E. G. Berneike (C), Research Engineer, Birmingham Tank Co., Birmingham, Ala.

M. O. McKinney (C), Local Manager, General Electric Co., 711 Power Bldg., Chattanooga, Tenn.

G. N. Robinson (C), Sales Agent, General Electric Co., 809 17th St., Denver, Colo.

David Wingate (C), Works Chemist, Stewart & Lloyds, Ltd., Coatbridge, Scotland.

Carl Wineland (D), Electric Welder, Minneapolis Steel & Machinery Co., 5041 18th Ave. S., Minneapolis, Minn.

HONOR LIST

January, February and March, 1925

Sponsor	Classes
D. H. Deyoe	16 Class C
R. D. Reed	7 Class C
J. G. Lincoln	2 Class B 3 Class C 1 Class D
Wm. Spraragen	2 Class B 1 Class C 1 Class D
R. E. Wagner	4 Class C
H. S. Card	1 Class B 1 Class C
E. J. O'Connell	2 Class D
W. W. Barnes	2 Class D
R. K. Randall	2 Class D
C. A. McCune	1 Class B
H. P. Doud	1 Class B
S. W. Miller	1 Class B
J. C. Horstman	1 Class C
W. S. Sprau	1 Class C
H. M. Schriefer	1 Class C
E. Vom Steeg	1 Class C
J. W. Belanger	1 Class C
V. J. Chapman	1 Class C
R. P. Palmer	1 Class D
H. E. Hollis	1 Class D
Dave Gibson	1 Class D
Mark Haines	1 Class D

SECTION ACTIVITIES

New York

The final meeting of the New York Section will be held in the Engineering Societies Building on May 12 at 8 p. m. Every effort has been made to make this meeting the most interesting of the whole year. Through the courtesy of the American Brass Company, their five reel moving picture film "From Mine to Consumer—A Story of Anaconda" will be shown. A wonderful opportunity is thus provided for our members to go on a conducted tour through the plants of this company and see the various operations from the mining of the raw material to the manufacture of the finished product. In addition there will be several papers on welding of cast iron with bronze electrode. Refreshments will also be served. The New York section cordially invites all the members of the American Welding Society and their friends to attend this final meeting.

Pittsburgh

The March meeting of the Pittsburgh section was scheduled for March 27, at which time Mr. Stanley Crute, President, Advance Welding Company, Neville Island, Pa., was to present a paper, illustrated by lantern slides, on "The Application of Welding in General Repair and Construction Work."

Cleveland

The March meeting of the Cleveland Section was held on the 17th at the Hotel Winton. The principal speaker was Mr. S. W. Mann of the Kleinhans Company, who gave an interesting account of large cast iron jobs that he had welded and spoke on so-called "Precision Welding." The program for the April meeting will probably include an address by Mr. Boom of the Boom Boiler & Welding Company on some aspects of the job welding shop.

Boston

The annual meeting of the Boston section will be held at the River Works Plant of the General Electric Company on May 21. This is to be an afternoon and evening session. Over 500 guests are expected, including manufacturers, manufacturing engineers and shop superintendents. A diversied program has been arranged to be of interest to all those present. Some of the most prominent people connected with the American Welding Society are scheduled as speakers.

Chicago

The April meeting of the Chicago section was held on the 3d. Mr. George Rose of the Oxweld Company presented a moving picture on the "Applications of Welding and Cutting." Mr. R. B. Fehr of the Rail Welding & Bonding Co. presented a paper and moving picture on the "Application of Carbon Arc Welding to Rail Joints."

Philadelphia

Mr. S. W. Miller of the Union Carbide and Carbon Research Laboratories and also Past President of the American Welding Society, presented at the March meeting an interesting paper on the subject of welded pressure vessels. Mr. Miller gave a most excellent blackboard talk on the construction of joints in pressure vessels.

San Francisco

The March meeting of the San Francisco Section was scheduled for the 20th. The evening was devoted to a report from the Section's Committee on Welding Structural Steel. Mr. G. O. Wilson of the Standard Oil Company was to have charge of the meeting and was to present samples to illustrate various points in connection with the report.

Western New York

The March meeting of the Western New York Section was held on the 10th. Mr. H. A. Woofter, Electrical Engineer of the Thomson Electric Welding Company, gave an illustrated talk on the resistance welding of various kinds of metal, ferrous and non-ferrous. Samples were also shown. The list of new officers are as follows: Chairman, Robert Siemer, Allan Mfg. & Welding Co.; Vice-Chairman, J. H. Baumer, Rochester Welding Works; Secretary and Treasurer, Carl D. Miller, Burke Electric Co.; Directors for 3 years, P. W. Kromer, Air Reduction Sales Co.; Howard D. Thomas, Merchants Despatch Transportation Co.; Director for 1 year, George B. Histed, Rochester Gas & Electric Co.; Director at Large to represent Section at Directors' Meetings of Society, Gideon W. Swan, J. A. Roeblings Sons Co.; Section representatives to American Bureau of Welding meetings, Ernest Bauer, U. S. Light & Heat Corp.; P. E. Haynes, Linde Air Products Co.

Detroit

The March meeting of the Detroit Section was held on the 25th. A film was shown by the Air Reduction Sales Company covering the make-up of acetylene and other constituents used in acetylene cutting and welding. The following Executive Committee was elected by the Section: 3 years, H. M. Gould, Detroit Street Railways; C. L. Finch, Detroit Range Boiler Co.; 2 years, O. L. Smith, Weldit Acetylene Co.; W. C. Sprau, Barnes Wire Fence Co.; 1 year, J. G. Lincoln, Lincoln Electric Co.; C. R. Richards, Welding Engineer.

Positions Vacant

V-21. Welder wanted with at least five years' experience in job welding shop, principally automobile work; must be expert on cast iron and steel, expert on preheats, who has welded cylinders cracked internally, built up worn valve seats, etc. Knowledge of aluminum welding, chassis straightening, electric welding and boiler work, desirable but not necessary; salary to start, $50.00; location, New York; chance for foremanship. Write all details just where you worked and what you did for the past ten years in confidence.

V-23. Assistant Executive. Opportunity for real live wire to connect with general repair welding and radiator works in fast growing city in north New Jersey. Established eleven years. To branch out owner needs reliable assistant executive. Capital not essential. Best location and most up-to-date equipment. Man of good personality and some experience can make unusual connection as active partner. Give particulars of past experience, age and monthly income expected.

V-24. Desires services of a young man who is familiar with welding shops in metropolitan district to sell welding rods and accessories on a commission basis with very good prospects for future development.

V-26. Wanted, a good man to sell welding and cutting apparatus.

V-27. Go-Getter wanted. Need a man to go out and get business for my welding repair works in Brooklyn, N. Y. We do electric and oxy-acetylene welding.

Services Available

A-31. Acetylene Welder. Has had 15 years of experience as a welder with good all around experience in the following lines: shipbuilding, boiler and tanks works, railroad, machine shop and steel mills. Have also worked during the past 8 years in same fields as electric welder. Am at present employed as an electric and acetylene welder. Have also acted as welding instructor in the British Navy. Am 35 years of age.

A-32. Welder desires position. Has had twelve years' experience at welding in all its branches, acetylene electric and thermit. This experience has been obtained on diversified work usually found in a shop that is the largest in South America. Nine of the twelve years' experience has been in the capacity of a foreman. Am forty years old and can speak Spanish and Danish as well as English.

A-33. Foreman or welder desires position. Has had about thirteen years all around experience as an oxy-acetylene welder. Recently resigned from Mechanical Division, Dept. of Street Cleaning, City of New York. Was employed with the City for five years on general plant repair, automobile and other rolling equipment. Can weld aluminum, cast iron, etc., and understand preheating.

A-34. Master Welder. Expert welder desires position as assistant master welder for a railroad. Had executive experience before welding. Can make large savings in production as the result of ten years experience in welding.

A-35. Expert welder desires position. Have had 17 years experience as acetylene welder, 11 years as welder on locomotives in New York Central repair shops, 4 years as foreman of the repair of all kinds of welding and cutting in the steel car shops, one year as head repair man on all makes of welding and cutting torches and gages and one year as general welder on all kinds of work. Have also been doing electric welding as well as acetylene for the past year.

Discussions to Be Presented at Technical Session, Annual Meeting, American Welding Society, April 24, 1925

Note: The technical session will be devoted to a symposium on two subjects, namely—1. Methods to be employed by various industries in inspecting their welding work. 2. Methods employed by various industries in checking up and testing the skill of their welding operators.

There follows the discussions of individuals from various industries on these two subjects.

Carbon Arc Welding Methods of the Chicago Surface Lines

JONATHAN WOLFE*

The general subject assigned to me for this paper is that of the welding of rail joints, particularly with reference to the inspection of welds and methods used to determine the operators' skill. The subject is broad and I will confine myself principally to the carbon arc process of seam welding rail joints and to the methods developed and practiced in our Track and Roadway Department.

In order properly to understand our reasons for adopting the seam welding process, a short synopsis of the history of welding on our system should prove of interest.

This system comprises four separate surface street railway companies operating within the City of Chicago under the so-called "Unification Ordinance" which became effective Feb. 1, 1914, totalling 1071 miles of single track.

For the ten or twelve years prior to 1907 practically all rail joints were cast welded. In 1907 the use of the Lorain electric bar weld (a resistance weld applied under a hydraulic pressure of about 45 tons) was begun, except that in the southern section of the city cast welds were continued until 1914. A total of approximately 183,500 Lorain bar welds were welded under contract by them, not including free reclamations.

A chart made of 175,000 joints, covering from one to ten years of service, showed less than 1 per cent total breaks per year.

A few Thermit welds of the old non-insert type were installed in 1911 for experimental purposes. During 1915 approximately 500 Thermit welds of the insert type were installed and last year we installed 643 additional insert Thermit welds on several of our extensions.

Seam welding of rail joints by the carbon arc process was begun in February, 1919, and 905 joints were welded during the first year. With the many improvements developed in this process since that time we have continued to use seam welds and have installed over

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45,000 joints to date. There are now nine equipments in daily service, used both for joint welding and for spot welding worn special trackwork. Three additional Type WW equipments have been purchased and are being put into service.

The seam weld has proven particularly fitted for the reclamation of the scattered broken joints. The work can be done during the daytime when better inspection of the work can be made, there is no need for the installation of temporary crossovers and car operation is interfered with very slightly, cars being permitted to pass over the joints after completion of each seam. Considering that rails ranging from new to those almost worn out have been seam welded, our percentage of failures is quite low. On several extensions and renewals where new rail was laid, these welds having been in service from one to three and a half years, we have had no failures to date.

Inspection of seam welds is an extremely important factor if uniformly good results are to be secured and unless the welding operators have been thoroughly instructed until they follow the rulings and approved methods of welding, the joints will certainly not hold up as long as they should. With Lorain bar welds, which were welded under contract, and with the Thermit joints, the principal part of which consists of a chemical reaction, the inspection is much simpler as there are fewer variables which can affect the quality of the weld.

Since these latter welds were all installed under contract, there is a double inspection and defective joints can be replaced at the manufacturer's expense. Seam welds, on the other hand, are installed by our own employees and the quality of the welds secured rests entirely with us. Inspections must be made constantly and any careless work or departures from standard practice which would result in decreasing the ultimate life of the joints must be corrected at once. By these inspections and through discussions held at the welding meetings, we are continually increasing our knowledge and adding to the skill of the operators.

Of primary importance in securing a good joint is the preparation of the joint before welding is begun. The ties must be firmly imbedded in the track foundation and the rails fastened securely to the ties so there is no movement in either ties or rails. With the best possible welds using the toughest electrodes available, the number of failures will be much greater if the rail ends are working up and down under the passing cars, as the weld would be subjected to alternate strains that must eventually crystallize and crack the seams.

Welding plates must be made so as to fish perfectly with the rails —we are using practically all machined plates—and where plates must be upset to connect with worn rails or rails worn different amounts, the corner is planed square so that the worn rail having the thinner head will be supported to the end of the rail.

To determine the proper size of the joint plates for seam welded

joints with various girder rail sections, no information of this nature being available, we followed these general rules shortly after beginning the use of this process:

1. The cross-sectional area of the two bars at the joint should at least equal the cross-sectional area of the rail to be welded.

2. The combined lengthwise sectional area of the four welding seams on either side of the rail joint (assuming ¼-in. penetration) should equal the cross-sectional area of the rail to be welded.

Although no consideration was given to the relative stiffness of the plates as compared with the rails, these rules have been found adequate in that failures from the bars breaking in half or of the joints pulling apart at the seams are very rare. With minor revisions, our present practice with reference to thickness of plates and lengths of seams conforms to these rules.

Care must be taken that the plates are put on the joint properly so that they will be vertical and the sloped edges engage the head and base of the rails evenly. The bolts must be installed and tightened as far as they will turn without stretching. All joint plates and rail ends, whether new or old, should be vigorously brushed with a stiff wire brush and if necessary, cleaned with a file and chisel. Where compressed air is available, I would recommend the use of a portable sand blast for cleaning both rail ends and plates. Any rust, scale, concrete or dirt in or along the seams to be welded will not only lessen the depth of penetration and form inclusions that may start seam cracking, but may keep the plates from having a good mechanical fit and thereby introduce additional strains in the joint.

Positive instructions have been issued to all welding operators that they shall refuse to weld any joint which is not good mechanically or where the rails or ties show movement when cars are passing. Every foreman in charge of preparing the joints understands that the welding operators have the authority to pass up any joint which is imperfect. We uphold the operator in this matter as we found that if we show confidence in his judgment he takes pride in his work and endeavors to see that his welding is of the best quality.

Rail ends should be tightly butted together and under compression before welding is started. Where possible this should be accomplished without the use of insert shims on new construction work the rails can usually be driven back by using wedges in the joint ahead. On reclamation work the cut-in piece may be installed at colder temperatures than when welding is done, in which case the ends are usually so tight that no insert can be inserted. We carry inserts in stock and with each welding equipment, ranging in thickness from 1/32 in. up to ⅜ in. made to conform in section to the heads of our standard rails and 1 in. x 2 in. shims for odd rails. Where there is any opening between the rail ends which cannot be closed otherwise, we drive in the largest single shim re-

quired to give a tight joint, first driving temporary wedges under the bases of the rails to widen the top part of the opening. More than one insert is not used at a joint if possible to avoid it.

We have found that joints of the same kind welded in cooler weather have held up better than those welded in hot weather. Our latest practice on new construction or on rail renewals is to weld at night or during the early morning when the rails are laid in the warmer months, thus both securing compression at the rail ends and lessening temperature strains during cold weather.

When the joint has been properly prepared and inspected by the operator, welding of the seams is started. Our standard welding gang consists of five or six men, depending on the density of car and vehicular traffic. The welding operator and two helpers are with the welding machine, one helper taking care of the pole hooking onto the trolley wire and watching traffic. The other helper supplies the operator with welding electrodes and sharpened carbons, watches the machine and takes care of the welding screen. Where traffic is very heavy an extra man is used as a watchman. A grinder operator and one helper run the Atlas rail grinding machine with which all joints are ground to a smooth surface. A four-wheel rubber tired trailer is used for transporting the equipment, the welding machine being mounted on one end, the tool box on the other and in the middle, which is depressed, is space for carrying the Atlas grinder.

The upper seams are welded to within 2 in. of the ends of the plates, the lower to within 1 in. or less. The so-called "AA" method is used, with a double seam on the middle 8 in. of the upper seam and a gap of 6 in. left unwelded on the lower seams with about 3 in. of double seam each side of the gap. The amperage used varies from 275 to 325 amperes, depending on conditions at the joint. The exact adjustment of the resistances is left to the judgment of the operator, who determines by the way the electrodes flow when he has the correct adjustment. The length of arc used is about $\frac{3}{8}$ in.

A large percentage of the joints welded on reclamation work are upset various amounts and as these plates are made with $\frac{1}{8}$-in. variations in the upset, it frequently happens that there is a considerable difference in the height of the rail ends when the joint is prepared and ready to weld. We have found that the pounding of the cars over these joints while the different seams are being welded and before surface welding with high carbon is likely to start seam cracks. Therefore, whenever there is any pronounced difference in the rail end heights, we build up the top surface of the joints with high carbon electrodes, using the metallic arc process, and grind the joint before starting the seam welding. After the seams are welded we again grind the joint slightly to make sure that the finished joint has a smooth even top surface.

For the inspection of the finished joints we have built up from

experience a method which is satisfactory and has resulted in greatly improving the quality of the joints. It does not, however, cover the testing of electrodes, types of welding plates or methods of welding employed other than in actual service tests. We may assume that the manufacturer's tests on the foregoing are correct for his existence depends on the continued use of these joints. Except where our conditions do not permit, we are guided in our practices by his recommendations, supplemented by such tests as we deem advisable.

Certain theoretical tests, such as the tensile, bend, drop, repeated impact, etc., are properly the work of the Committee on Welded Rail Joints, and such tests have already been made by them or are in progress. We have followed and will continue to follow the committee's reports covering results of tests very closely, using these results as a guide, except where necessary to modify them to suit our conditions. However, the above tests as published in Progress Report No. 2 show a great variation in strength for the seam welds, and this indicates the great need for the investigation of variables in seam welds as outlined in Exhibit A of the committee's minutes of Sept. 19, 1924. The tests to be made cover the cross-sectional area of seams and proper penetration, kind of welding wire, effect of preheating and postheating, use of base plates and methods to secure tight rail heads.

Our welds are carefully inspected by both the superintendent of welding and by the welding foremen, the latter also laying out the work to be done by the operators and making out daily reports of the work done. The points covered include seeing that the seams are welded smoothly and at a speed of from 4 in. to 6 in. per minute—that seams are placed so as to be evenly divided between the plate and the rail, and are free from pits or deep holes where started and finished. Particular attention is paid to the grinding to see that the top surface is perfectly smooth and, where necessary to surface weld, that the cup or low spot is entirely removed. With above conditions met, the joint should hold up satisfactorily, providing, of course, that proper plates and good quality electrodes are used.

We have conducted tests at different times to determine the proper kind of electrodes. Welds were made on mild steel plates and tested mechanically and chemically. For several years we used the American Bureau of Welding Specification E-No. 1-A for low carbon electrodes. This specification, which was made primarily for metallic process shop work, is not sufficiently rigid in my opinion for the requirements of a welded rail joint, subjected to the continual shock and vibration of passing car wheels, where ductility is so all important. I mean ductility or toughness that will continue for the life of the rail and not permit crystallization of the weld to cause the seam to fail before the rail is worn out. For the last year we have used the coated low carbon electrodes

(Grade 200) having a manganese content around 1 per cent, and are getting a better, tougher seam than before. The determination of the best electrode to be used for the welding of joint seams, is, I believe, one of the most important duties remaining for the Welded Rail Joint Committee.

There are some simple tests, on the other hand, which can be used to advantage by the individual street railways in determining ductility of the seams, etc. To what extent such tests are used will depend on the viewpoint of the particular railway. The following are just a few tests that, while not new, are simple, easily made and give comparative results for determining proper grades of electrodes:

(a) Weld together two "V"-ed pieces of mild steel, subjecting both parent metal and the weld to mechanical, microscopic and chemical tests covering structure, hardness, composition, etc.

(b) Weld at right angles to each other two plates of mild steel, place one in a vise and determine to what angle the other plate can be bent before fracture occurs.

(c) Weld upper seams of sections of welding plates to the head of standard rails, the plates being fished into the rail. The amount of pull necessary to bend the plate out from the rail until fracture occurs and the angle at which fracture occurs can then be determined.

We believe that the best tests are service tests under actual track conditions, and many such test joints have been installed by us from time to time covering various methods—and from them we have been enabled to eliminate weaknesses and objectionable features. But service tests require time and introduce variables which make comparisons difficult between different kinds of joints.

Our experience has indicated that with bare electrodes a better weld is secured by using flux, and instructions to the operators require its use. We use the powdered flux furnished by the Rail Welding & Bonding Company. One advantage of the coated electrode is that the flux is furnished in uniform quantities.

We hold meetings at which all division superintendents, welding foremen and welding operators are present, and at some of these meetings have samples of welds, test pieces, etc. In the discussions which follow many good points are brought out, instructions are issued covering future work and the operators brought in touch with each other's work.

Methods used for testing the skill of the operators are somewhat involved with the course of training for operators, and our practice is considerably different from that commonly in use for shop work owing to the difference in the nature of the welding done.

To accurately describe these methods it is important to go back into the origin of our welding. Arc welding was first started in 1913 with two Indianapolis resistance welders used for building up worn special track work. An additional equipment of this type

was purchased some two years later. When seam welding of joints was begun in 1919 our first carbon arc welder was an accomplished welding demonstrator. As additional equipments for carbon welding of joints were purchased it was necessary to put on more arc welders. The second operator was one of the resistance welders and his carbon arc training was obtained as a helper under the experienced demonstrator. We have since employed two more demonstrators, their skill being checked and our methods taught them by the first operator. Since the position of arc welding operator is considered desirable and gives steady work the year around, few openings for additional operators occur except when an additional welding equipment is put into service. So the only practicable school for the instruction of welders which we can use is that of training the helpers in each gang. These helpers are picked men, and they are given the opportunity of doing welding under the supervision of the operator. Thus when the operator is off for any reason, the helper can proceed with the welding.

It is also our policy to advance metallic process welders, but they must first serve an apprenticeship under the carbon arc operator until they master the carbon process as applied to the seam welding of joints.

The helpers are first taught the electrical principles in the operation of the welding equipments and the necessity for keeping their machines in good running order. Each operator has an equipment assigned to him and the responsibility of taking care of it is put up to him. Quite a rivalry has developed among the operators in this respect, each one trying to keep his equipment in the best condition. Operators are only permitted to make minor repairs to the electrical equipment, more serious repairs being taken care of by our power tool men. Every equipment is given a thorough overhauling in our shops at least once in six months, a card index system being used to determine how frequently the equipments have been overhauled.

The skill of the operators is mainly checked by inspection of the welding done by them and by the way in which their joints hold up under service in the track. Each operator has a metal stamping die with an individual letter with which he must stamp every joint welded by him, and it is usually possible to identify any particular joint. It is comparatively easy to judge the quality of seam welding by visual inspection, as poor work shows up very plainly in uneven and ragged seams, burnt metal or deep holes in the seams. We also rely to a large extent on the meetings, previously mentioned, which are held in our office at stated intervals. Here are brought up criticisms of any welding being done, with samples of such work shown, and means to correct faults brought out through discussion.

Too much importance cannot be given to these general meetings

up worn special track work. An additional equipment of this type

as there are always some good new ideas brought out for trial or which have been developed by some operator. Our system being so large, about the only time some of the operators see each other and learn of the work the others are accomplishing is at these meetings.

Our welding foremen on their frequent visits to the operators spend sufficient time with each operator to check up the practices followed by the latter, correcting any wrong methods which may be used. Once or twice a year engineers or others from the Welding Company visit us, spending some time with each operator, and give the operators the benefit of their latest developments toward improving the joints.

The practice followed in the preheating of joints is to preheat with a 5-gal. Aeroil Pressure Tank whenever the temperature is freezing or below. Also when the rails or plates are damp, frosty, wet or covered with mud the joint is preheated in order to dry it out. Definite data regarding the effects of preheating joints to be seam welded seem to be entirely lacking, and we are at this time of the opinion that the chief function of preheating is to dry out and remove the chill from the rails and plates. We do not attempt to secure any definite temperature in preheating other than to thoroughly warm and dry out the joints.

Welding of Rail Joints

J. C. LINCOLN*

Experience has shown that in the ordinary street railway, in paved streets, the joint fails long before the rail is worn out. When a joint gets loose in a paved street, it is expensive to open the pavement to repair it, so in most cases the joint is allowed to pound until the ends of the rail are battered up and in some cases broken.

The noise and jolts due to the car passing over a large number of bad joints compels the railway company to replace the track before more than a small portion of the life of the rail has been used. If it were possible to make a joint that lasted as long as the rail, I do not think it is an exaggeration to say that the cost of maintenance of way would be much less than half what it is now.

The use of such a joint would save the street railways of the United States millions of dollars every year. There are several proposed solutions of this problem.

One is the butt welding of the rail into one long piece before the rails are placed on the ties. This process is rather new and is open to the objection that an ordinary joint must be installed once every

*President, Lincoln Electric Co.

Too much importance cannot be given to these general meetings

block or so, for this butt welding process shortens the rail at each joint by the amount of the flash.

A second process is the thermit weld. This process supplies additional metal at a very high temperature between the rail ends and by fusion of the ends of the rail to the added metal produces a weld.

A third method is the seam welding of the ordinary fish plates or splice bars to the rails in the effort to make the joint as strong or stronger than the rest of the rail. This method has the advantage of being cheaper than any other so far proposed, if the joint can be properly welded. Many thousands of such joints have been in use for many years, showing that if the welding is properly done the result is satisfactory.

As I see it, the problem of getting a good weld in a rail joint is very much the same as all other welding. The electric welder is a tool for accomplishing a new result and the result depends on the skill with which the tool is handled.

A good many of us are willing to pay $2.00 or $3.00 a seat to hear Kreisler play the violin. The same people would pay twice as much to get out of the hall if I played the same violin. The fault would not be in the violin, but in the skill with which it was handled.

None of us would complain about the lathe if a poor or careless operator failed to produce satisfactory work. We would place the blame where it belonged, on the inexperience or carelessness of the operator.

The above will make it clear that the quality of work depends on the skill and care of the operators more than on any other one thing.

There are two methods of making seam welds. One the carbon arc method, and the other the metallic arc. The conditions that have to be satisfied in the welded joint are the same, whichever process for making the joint is used. These conditions are:

1. The weld between the fish plate and rail must have enough strength to resist the contraction strains in the rail due to the cooling of the rail in the winter.

2. There is a certain amount of liveload, due to the passage of the car over the joint, that will tend to produce compression strains in the weld over the upper side of the fish plate, and tensile strains on the weld on the lower side of the fish plate.

3. The action that apparently starts the failures in a welded joint, when there are failures, is the blow that is delivered on the head of the receiving rail by the car wheel as it passes over the joint.

If the heads of the two rails are not in exact alignment, there will be a real blow, the amount depending on the difference in height of the two rail heads. Even when the two rail heads have been ground after welding, there is a sudden transfer of load onto the receiving rail as the car wheel passes over the joint.

The fact is that when failure occurs in a welded rail joint, it

starts in a large majority of cases on the top directly under the head of the receiving rail. The importance of this fact cannot be exaggerated.

When the wheel strikes the receiving rail, there is a slight compression of the metal in the weld under this head and a subsequent corresponding expansion of the same metal. It is the inability of some welded metal to stand the alternating stress (slight though it may seem to be) that is the weakest spot in electrically welded joints.

It is easier to make a joint strong enough to cause the rail to break outside of the joint than it is to get a welded joint to stand the pounding, due to the wheel passing to the receiving rail, even though at first this force seems insignificant. It is the fact that welded joints start to fail on the upper seam under the receiving rail that makes it necessary to find a laboratory treatment that will produce similar failure before the study of how to improve such a joint can progress as fast as it should. Tensile tests up to 1,000,000 lb. are valuable in showing if the weld is made over the whole surface or not, bending tests and drop tests are useful for the same purpose, but all these tests cause the joint to fail in other places and from other causes than joints actually fail in practice. A repeated impact of blows on the receiving rail may make the rail fail where

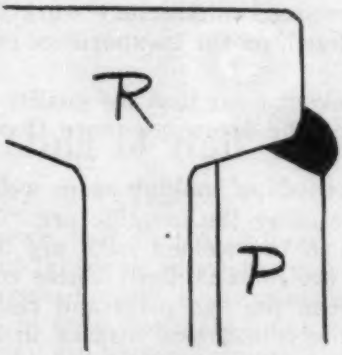

Fig. 1

it does on the street, and, if so, the results of the repeated impact test will be of great value in improving the joint.

Consider the sketch, Fig. 1, in which "R" is a partial section of the rail and "P" a partial section of the fish plate. The contraction in volume from molten iron to the same iron cold is about 7 per cent or nearly 2 per cent along any line drawn through the weld.

As the weld metal cools, it must either stretch this 7 per cent or cracks will appear in the weld metal. Any metal that cracks as it cools is clearly useless. What actually happens is that the weld metal stretches as it cools an amount equal to the contraction due to the cooling, but there remains in the weld metal after it has cooled strains due to the stretching of the weld metal. In most

cases, the weld metal is sufficiently ductile to undergo a further stretch or elongation and relieve these strains.

In the cases where failure occurs, the weld metal is not ductile enough to stretch and relieve the strains, and cracks develop which extend as the joint is used and finally cause the failure of the joint.

The question remains then as to the best method of getting ductile weld metal. Experience on test pieces shows that if the weld metal is annealed from the critical point down slowly, that the ductility is improved. In most cases it is impractical to anneal a rail joint after welding. In the present state of the art the best way to get ductile metal in the weld, and therefore, good joints may be stated as follows:

1. First and most important, a good, conscientious, experienced welder operator who has been trained.

2. A short arc and proper fusion of the surfaces, and this is only possible with a good operator.

3. A good wire not over 3/16 in. diameter. The welding of the top seam is very largely a job of making a vertical weld and for this work a 5/32 in. or 3/16 in. wire with from 175 to 200 amp. gives better results than can be obtained with ¼ in. or larger wires.

4. The surfaces of the rail and fish plate should be cleaned of dirt and thick rust. When the rail and plate are both new the thin coat of black oxide on the surface does not have to be removed, but on old rails and old plates the surfaces should be carefully cleaned.

The short arc with proper fusion is the most important single requirement and this takes a skilled operator.

Before a welder is allowed to weld a joint that stays in the track, he should be able to make a satisfactory overhead weld which requires a short arc and proper manipulation. Then he should weld a number of test joints and have the plates wedged off so that he can see what he has been doing.

When he has acquired sufficient skill so that it is almost impossible to wedge the plates off a test joint, it is safe to let him make joints that are to stay in the track and not before.

Rail Joint Welding

H. M. STEWARD*

The rail ends are milled square laterally and have an undercutting of 1/64 in. in 12 in. Joint plates are of rolled section of medium carbon steel with a carbon content of 0.30 to 0.40 per cent.

The drift pin method of joint assembling is used whereby the rail heads are brought under moderate compression. Between the

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rail heads we place a soft steel insert 1/16 in. in thickness. This insert projects ⅛ in. above the running surface of the rail and after the joint is welded the insert is peened over and the joint ground off by a small reciprocating track grinder. Rail joint base plates are used and are welded to base of the rails. The joints are welded by the carbon arc process "B" method of seam welding. The welding rod used is 9/32 in. in diameter by 24 in. in length, of the following chemical composition:

carbon	.12%
manganese	.41%
phosphorus	.009%
sulphur	.050%
silicon	.07%
chromium	.06%

The rods are flux coated. About 1½ in. of welding rod is used per inch of seam. The top seams are double welded for part of the distance. The seams are preheated and postheated by means of the carbon arc. This is done by drawing as long an arc as possible and moving it slowly along the seam.

The welding current varies from 175 to 200 amperes at 25 to 30 volts. The length of the arc is approximately ⅜ in. A welding crew consists of two men per machine. Only one man welds at a time. The operators relieve each other at intervals.

Before men are assigned to regular joint welding they first receive instruction in the care and operation of welding machines and make up test joints under the direction of competent instructors. These test joints are broken apart that the men may see the effect of the welding. When the men are considered competent to weld joints they are assigned to one of the regular crews for further instruction and, if they pass the final test, take their place as regular welding operators. The Boston Elevated Railway has no means at its own disposal of testing any joints other than by the destruction method and this is done occasionally by the operators.

From time to time, however, full sized joints or shorter test specimens are carefully and scientifically tested at either the laboratory of the Rail Welding and Bonding Company at Cleveland, Ohio, or at the Massachusetts Institute of Technology. In addition to these tests the results obtained by various methods of welding, variation in strength of current used, welding rods of different composition or of test sizes, etc., are tested by our chemists, Saunders & Franklin, of Providence, Rhode Island. These tests consist of chemical determinations and micro-photographs to study changes in the structure of the rail metal, joint metal, and welding metal.

A careful and vigilant inspection of welding is made by the welding foremen during the welding and after the job is finished.

Rail Joint Welding

H. F. A. KLEINSCHMIDT*

In the bar weld joint, the fact that the welds are under the bar makes it impossible to see the weld and there is no way of knowing by inspection whether a good weld has been made or not. We therefore do not inspect joints except to see that the joints are straight and properly finished.

It is a very simple matter to make a resistance weld and the human element enters into it probably to a less degree than in any other form of welding. With a current of the proper voltage manipulation of the pressure while heating and keeping the current on a definite time, applying pressure up to a certain amount per square inch when the heating period is over and the current has been cut off, and maintaining the pressure a certain length of time while the metal is cooling, is all that is required to know definitely that a good weld will result no matter who the operator is. The voltage is read on a voltmeter and the current is held steady at the voltage required, time is read from a clock, and the pressure from a pressure gage, so that there is no "guess work" about it. All these items are recorded on a welding record and it is the inspection of this record rather than the weld itself by which we judge whether our operators are doing good work.

While the tests made under the direction of the Committee on Welded Rail Joints have shown that the weld at the center is poor, we were well aware of this years ago, and it is not essential that this should be a good weld, our experience has proven over and over that it is more important, from the standpoint of getting a good joint, to keep the bars as hot as possible at the center while the end welds are being made in order that the contraction of the bars on cooling will bring the abutting rails tightly together than it is to get a good weld at the center. The end welds, which take all the strain, are good welds, however. That this is so is shown by the fact that it is an extremely rare occurrence to have an end weld fail. Also that it is not important that the center weld be good is borne out by the fact that in practice we do not have joints break through the bars (where they all broke in tests) once in 100,000 cases. If we should stop to hold the center weld under pressure while cooling, which would result in a good weld, we would not obtain that contraction in the bars that is essential to keep the heads of the two rails tightly abutting, which is the most important feature of any rail joint.

In the butt-weld we can and do inspect the weld directly, and can judge by the amount of upset whether or not the proper degree of heat was reached to make a good weld. In case of a very small upset, which would indicate that the weld was not good, the joint

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is cut apart either by passing an oxy-acetylene flame through the weld, or by cutting down through the weld with a hack saw, and then rewelding. But here again the human element has little to do with getting a good weld. If the current is held at the proper voltage, it takes just so much time to make a heat, and pressure is applied according to a pressure gage, these items are recorded, and if the proper procedure is followed there is no doubt as to the quality of the weld, regardless of the operator. Of course we do have a failure occasionally. On the welding done for the Third Ave. R. R. in New York last year, out of 698 welds made there were two failures, one on account of using sand mixed with the clay for making the molds. This was due to exhaustion of our regular supply of clay, and the attempt to use a different kind of clay which required sand to make it hold together. Our men tried this on one joint; this weld parted the next day. Borax has a strong affinity for silicon and if too much silicon is absorbed by it the conductivity is affected to such an extent that the proper amount of heat will not be transmitted to the rail and an imperfect weld will result. In the other case our welding record plainly showed that not sufficient time had been allowed to make the heat, probably through an error on the part of our operator.

In the butt-weld process there is a very pretty play of opposing forces which can be read on the voltmeter, provided the current on the line is fairly steady. The conductivity of molten borax increases as its temperature rises, so that the voltage decreases as the temperature increases. Just the opposite is true however of rail steel, as its temperature increases as resistance increases and very decidedly so the nearer the melting point is reached. As the rail ends approach a welding heat a point is reached where the increased resistance of the steel overcomes the increasing conductivity of the borax and the voltage begins to rise. We have found by experience that if the current is kept on about one-half minute longer after this reversal of the voltage takes place, that a good weld will result. Of course this cannot always be depended on in welding rails where the current supply is drawn from the trolley with its unsteady voltage. We therefore depend more on the time element, as there is very little danger of burning the steel when the rail ends are immersed in the molten borax.

On account of the unequal distribution of the metal through a section of rail, especially a girder rail, we find it necessary to reheat the web of the rails after the butt-weld has been made to relieve a strain which tends to separate the head from the foot of the rail, producing a lengthwise fracture of the rail web across the weld. This is a strain that is inherent on all rolled rails, and is probably added to by us when we apply end pressure to force the rails together in the process of butt-welding. By postheating the web above the critical temperature this strain is relieved and I do not know of a single case of web fracture where this postheating was done.

Rail Joint Welding

R. H. DALGLEISH*

Two methods of electric welding are now used quite extensively for welded rail joints, the metal electrode and the carbon electrode methods. The welder on this class of work is at a great disadvantage in that he is necessarily in an uncomfortable position, disturbed by vehicular traffic, and on a majority of jobs he is interrupted by passing cars. This has a tendency to distract the welder from his work and makes it very hard for him to keep his mind on what he is doing. A good welder on shop work is often unable to do good work on rail joints in the street, so it is necessary to use great care in teaching them how to do this work. Welders are first taught to weld in the shop in the position required in the street. This is done to get them used to this method before subjecting them to the traffic distraction. They are then sent out with an experienced welder until they are able to work by themselves.

When preparing rail joints for welding, the rails are first cleaned of all scale, rust and grease, as are also the joint plates. The plates are then bolted to the rails and the rails carefully lined up to get the gage line straight and the joint even at the top. After welding, the rail head is ground with a reciprocating grinder in order that there will be no uneven joint for the wheel to come in contact with.

The ends of the rails should be carefully cut to make a tight joint before the plates are welded to the rails. In order to insure tight joints between rails, the spacing of the holes in the rails is slightly greater than in the plates, and drift pins driven in to draw the rails together before welding. The heat from the welding, of course, tends to expand the rail and draws the joints up still tighter.

The welding is started on the outside top seam and next the inside bottom seam; next inside top seam and last outside bottom seam. This distributes the heat somewhat and has proved to be quite satisfactory, although I am quite sure welding the seams in other order will be satisfactory so long as both seams are not welded on one side of the rail before any welding is done on the other. When this is done, it tends to kink the rail.

A 3/16 in. rod of low carbon steel is used for metal electrode welding, with 125 amp. at 60 volts, about ⅛-in. arc.

After welding, inspection should be made of alignment of rails to see that the gage line is straight. The weld metal should be laid on in even layers and the uniform corrugations will show the metal deposited evenly. Examination should be made for burned spots in the seam. An examination of the seam should be made to see that the metal is evenly placed on both plate and rail, in order that the maximum strength may be developed at the joints. When rail

*Chief Engineer, The Capital Traction Co.

is welded in one length ½ mile or more long, the joint is subjected to severe tensile stress, in addition to the vibration set up in the rail due to the movement of cars over the rail. This requires careful work and inspection to prevent failures.

With the carbon arc method of rail joint welding, the skill of the welder is the predominating factor, and the difficulty in getting welders who will turn out uniform work makes it very diffcult to get satisfactory results. We have had so much difficulty getting uniform results with the carbon arc method that we have discon-

Fig. 1. Plates in position ready for welding

tinued the use of that type of joint and we are now using metal electrode welding for all seam welded rail joints.

After welding with the carbon arc method, it is almost impossible for an inspector to eliminate the bad joints due to the uneven deposit of metal, and the fact that on practically all joints burned spots may be found which may or may not be burned metal. In preparing joints for carbon arc welding, the plates and rail are treated in the same manner as in metal electrode welding. A deflector bar is used to deflect the metal into the seam. In some cases, a 9/32-in. rod of mild steel is laid in the seam and burned in place by the carbon arc. Another method is to hold a 9/32-in. rod in the left hand and the carbon pencil in the right hand and thus burn the metal into the seam.

A long arc with 275 to 300 amp. at 60 volts is used for this class of work, and with that much current it is important that the arcs

be moved at a uniform rate of speed to prevent burning the metal.

The average cost of this type of joint is as follows:

Joint plates, 1 pr.	$2.90
Welding rod, 1.8 lb.	.26
Carbon pencil	.05
Royalty	1.00
Welder, 1 hr.	.75
Helper, 1 hr.	.50
	$5.46

Fig. 2. Ready to weld

Fig. 1 shows the joint plates in position ready for welding and gives some idea of the difficulty in getting at the work. Fig. 2 shows the welder in position ready to weld with the deflector bar in place for carbon arc welding.

Track Rail Joint Welding

FRANK B. WALKER*

This discussion only treats of two points, namely:

1. Training of welders.
2. Inspection of finished work.

Whatever measure of success we have had with the Metallic Arc Process of welding has been due to what we please to call the Development of the Technique of Welding. When we began this

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process in 1921, we hired an exceptionally good welder to act as a welding instructor, and began the training of picked, green men.

Due to the volume of work and the press of time, we also hired experienced welders, when possible. However, probably 90 per cent of our total men were trained by our own instructor and were invariably better men than the so-called "experienced men" who came looking for positions.

In picking the applicant for training, we were particular that he be young, or at least not so old but that he was still mentally and physically flexible; was in good physical condition, possessing both hands and feet, as well as good eyesight, and hearing.

The trainee was first taught the difference between the two general types of welding machines, i.e. resistance and motor generator or dynamotor type, the class of work done by each and why; the polarity of the welding arc of each type, and in the case of the motor generator machine, how to change the polarity of the arc.

He was also taught the rudiments of the care and operation of the two types of machines, paying attention to the importance of cleanliness and lurbication, and with due emphasis on the fact that in *starting* a machine correctly the *last* thing done is to *apply* the power, while in stopping a machine, the *first* thing done is to *shut off* the power.

In addition to the above, the operator was continually importuned to develop (if he did not already possess it) a sense of pride in the appearance and quality of the work he was doing as well as the appearance and condition of the machine he was working with, and last but not least a sense of responsibility for "Safety First" as it applied to himself, the workmen busy around him and the public at large.

When it came to the actual handling of the arc, the two vital essentials of metallic arc welding, viz.: absolute cleanliness of all welding surfaces and the use of a short arc, were continually emphasized and held up before the operator, as the observance, or lack of observance of these two points, spells success or failure in this type of welding.

For our type of work the actual training of the men consisted of intensive training in a few simple exercises, as for example:

1. Striking the arc, without sticking the electrode, and breaking the arc without causing a deep spongy oxidized crater.
2. Welding parallel beads in a flat position.
3. Filling in the space between parallel beads by depositing a half moon bead. We do not allow the use of the straight or "inch for inch" bead.
4. Building up a pad of metal 3 in. x 6 in. x 1 in. in height in the flat position.

After the trainee became proficient in the above exercises, he repeated them on a flat plate, in the vertical position.

The last step was a repetition of these exercises on a flat plate in a straight overhead position.

The trainee was shown by observing the shape and color of resulting beads whether or not his arc was of proper length and whether the amperage or current gave the correct heat.

In connection with the above, the trainee was urged to become expert in his ability to handle the welding tools with either hand equally well. Under no circumstances was he allowed to hold the welding handle with both hands, but rather he was taught to develop freedom in the use of the welding arm, so as not to depend on any rigid or body support.

As an example of what can be accomplished by specialized intensive training under the direction of a competent instructor, we would cite the case of an absolutely green man, who due to press of time was trained to do first-class overhead welding in three days.

The above is but one out of many cases, for during the height of our rehabilitation work, we were operating two nine-hour shifts of 60 welders each.

The entire welding organization which took care of the welders and also an equally large force of surface grinders, aside from the division managers and roadmasters, consisted of an engineer in charge of welding and the welding instructor.

Our system of inspection as finally developed, practically made certain that every operator's work was under continuous inspection.

In the first place each welder was supplied with a stencil number which he stamped on each joint welded. These numbers were, of course, recorded so that anyone interested could tell immediately the operator doing the work. This practice gave the operator a sense of responsibility and had a tendency to do away with carelessness on his part.

To further check up the operator's work it is our practice for the foreman in charge of the track job, to test out at least one joint of each operator's day's work; the usual practice being to inspect all the joints, picking out those which are at all questionable, so far as appearances are concerned, and then trying to break them off by means of a hammer and wedge.

Then, of course, there was the continual inspection by the welding engineer, and welding instructor. These men were in communication every day, and arranged that between them all welding jobs were covered by one or the other every three or four days. This work being scattered over 640 miles of track, required 50,000 miles of traveling a year on the part of these men.

In addition a Winter Track School was held, which was attended by all engineers, managers, superintendents, roadmasters and track foremen. Among other subjects, track welding and bonding was thoroughly discussed by means of an illustrated talk. The various important points, such as the absolute necessity of clean welding surfaces and the use of a short arc were illustrated with

lantern slides, showing the appearance and quality of the finished work, using the short arc and also using a long arc. The distinguishing marks being very definite that once learned, our supervisory force did not need to be welding experts to tell from a finished bead, whether the operator used a short or a long arc, or used the proper amount of current. The welding instruction was in two parts, viz.: the illustrated talk and discussion in the morning and the practical application in the afternoon. In the afternoon, all those attending the lecture were taken in hand by experienced welders and actually taught the rudiments of handling the arc. Of course, they did not become finished welders or even good welders; but they did acquire considerable beneficial knowledge and experience which helped greatly toward the success of our joint welding.

The one outstanding point of all the various inspections was and still is, that if a joint for any reason did not look A-1, it was broken open; and if they all looked good, one or two were broken open anyway. This is rather rough treatment, but it does tell absolutely just how good a finished job we are getting. If there is any criticism or suggestion to make, we have the man's number on the joint to refer to. He is brought back, and the points under criticism shown him, and if necessary, he is given help to correct his fault.

This method of inspection was a big help in weeding out those welders who could not or would not learn to weld as we desired, for after a man had been thoroughly instructed and then had been checked up three or four times by means of broken joints, without showing any improvement, he was discharged.

The above methods of instruction and inspection, which so far as we can ascertain no other road has ever attempted, has made possible the welding and rehabilitation of many miles of worn out open and paved track which otherwise would have had to be rebuilt with new rail.

Our per cent of weld failures is about 1/10 of 1 per cent per year.

Gas Welding Practice

F. E. ROGERS*

Improvement of welding practice is largely a matter of eliminating the variables, that is, standardizing on everything that can be standardized. No welding shop can be efficiently supervised and controlled where a variety of torches and regulators is used. Every make of torch has individual characteristics and the gas pressures required vary with these characteristics. It is important, therefore, that whatever make of apparatus is used that it be uniform throughout. Then the supervisor or foreman can tell by inspection of pressure gages and tips whether his men are using tips and pressures suitable for the work in hand.

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Thus one set of variables is practically eliminated and the uncertainty of results simmers down to the personal equation of the welder.

Of course, it is understood that standardization should also apply to welding rods and fluxes when used. Obviously these should be of characteristics suitable for the work and the best that can be obtained.

We know that the gas welding process will produce sound work when the conditions are right and the operator is capable. By standardizing the conditions you will help the operator and in many cases will find that faults of practice have been due to faults of equipment conditions outside the control of the operator. Let us do everything possible to pin the responsibility for sound welds on the operator. When that is done, I believe that most operators will be able to show satisfactory work.

Welding Pipe Lines

F. A. LYDECKER*

When making ready to construct a welded pipe line it is important to make sure of the welders. Experience has shown that many who represent themselves as first-class pipe line men are mere novices and furthermore, cannot be taught. In a job of large extent, a foreman welder is necessary, and naturally, considerable care must be exercised in his selection.

It is to be expected that a welder will work to the best advantage when given freedom of movement, and to this end as much work as possible must be done above ground, and by rolling as long a section of pipe as convenient, enable him to work on the uppermost portion. Some welders become very skillful in welding a pipe joint in place without rolling, while others seem to be unable to master the trick, but can produce satisfactory welds by the rolling method. The foreman, therefore, must be careful to whom he assigns the joint work.

Pipe for welding purposes is usually bevelled at the ends although some engineers use square end pipe. Most welders seem to prefer pipe bevelled to the full depth, as it is thought this feature aids them in obtaining a full depth weld. Also, it is thought advantageous to leave a slight gap between the ends of the pipe, when lining them up for welding, to compensate for any drawing together during the process of welding and to assist in obtaining a full depth weld.

Building up, or reinforcing a weld above the surface of the pipe is considered good practice, as this compensates for failure to obtain full penetration and aids in producing welds as strong or stronger than the pipe itself. Carried to extremes, this process

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would be wasteful, but the extra expenditure of material in a reasonable reinforcement is amply justified by the results obtained.

As it is impossible to know fully how well a welded joint has been made without destruction and pulling in a testing machine, it is important to watch the construction of the joint as much as possible. The foreman must note the penetration being made, and the manner of fusion. The finished weld must be inspected for "cold shuts", porosity and depressions. It is considered a good plan to cut out a completed weld occasionally and let the man who made it break sections of it with a hammer to note the character of the interior of the weld.

After a suitable section of pipe has been completed, it is a good plan to apply an air pressure test, say at 50 lb. pressure, and go over each joint with soap suds. Leaks will be promptly shown up and indicate usually cold shuts or porous metal. If each joint has its maker's name painted alongside of it together with the date on which it was made, no doubt can exist as to the welder responsible for that particular joint, and the date will provide information as to the number of joints made per day.

Encouragement of the welder and getting him interested in the work to produce welds of the character wanted is desirable. Speed, while important, must not be obtained at the expense of good workmanship. A conscientious workman will produce a certain amount of acceptable work per day and a standard for the job can soon be established. A record kept of each man's work is helpful and the knowledge that such a record is carried will spur a man on to his best efforts.

Electric Spot (Resistance) Welding

J. W. MEADOWCROFT*

Before you can expect a high standard in Electric Spot Welding, you must first make a careful study of your Electric Spot Welding Machine and see that the switches, copper dies, etc. are in their proper condition to produce high class welds.

First check up the contact plugs in the switches and see that they are a uniform distance apart and that the copper contact plugs have a flat face at contact point so that all unnecessary heating of switch parts is avoided, and the condition of fibre being burnt out and switches falling apart is eliminated; also see that all copper dies are set the proper distance apart so as to get the proper amount of pressure at welding points and that the welding points are kept at the proper diameter to correspond with gages of metal being welded. Also check up the toggle on your machine when setting dies to see that it is in its proper relation with die points to obtain the necessary pressure, and under no condition, operate electric welding machines if die points are hot. If your die points do

*General Supervisor of Welding, Edward G. Budd Mfg. Co.

become hot, check up your water circulation and the length of the copper tube and no doubt you will either find that the water system has been clogged by dirt or that the copper tube is not long enough to prevent a pocket of water from forming in the water shank holder, which becomes heated and finally with no water circulation in your die points, you immediately begin to produce burnt welds. This last item should be watched carefully at all times, especially when you are changing dies because of the variation in the depth of holes in the various type copper dies used in the manufacture of your products.

Hand operated machines are so constructed that you can adjust the handle very easily and quickly and each operator should make the necessary adjustment at any time to assure himself that he is producing a standard spot weld.

If, in case your operation requires a foot treadle, same should be so arranged that you can use either foot for operating without losing your balance or position. It is when you lose your balance or position that you lose a certain amount of spot welds due to uncertainty in the amount of pressure.

Now that we have our machines fitted up to produce a high standard of spot welds, we must not lose sight of the fact that the pieces which we are assembling fit properly before spot welding. There is much stress laid on the design of the various products we manufacture so that same can be welded successfully, and to hold a standard in welding we must form our pieces regardless of shape or size so that same can be welded successfully with very little pressure or consumption of current. Many failures in spot welding can be attributed to the fit of pieces to be welded and not the art itself. Switches are so constructed on electric spot welding machines that the pressure can be applied before current is applied and although this is a very good invention and works out very successfully, we must not lay too much stress on forcing metals together and expect to obtain standard welds, or hold pieces to their proper shape. Pieces which are shaped, or have contours, are much more troublesome to spot weld, especially if the pieces do not fit properly as the condition and quality of welds made on irregular shapes depends on the position in which pieces are held while spot welding. Many times very deep indentions are made because of pieces not being held in their proper position for welding. This not only gives us a poor weld but it also gives us a vast amount of extra finishing which is very costly. On some interior parts, however, which are not exposed, the finishing would not be considered. Another condition also exists in spot welding irregular shapes and that is, holding the various shapes of pieces to the proper contours. Many times pieces will change considerably after placing numerous welds on same, and unless you take steps to change the shape or contours of pieces to allow for this contraction, your welded pieces will not be the proper shape. This is much more

economical than to simply spot weld the pieces together regardless of shape and then have a costly operation of straightening same by hand.

When pieces to be spot welded are formed, held to their proper shape while in process of spot welding, held properly at machine, while welding, dies, switches, etc. on welding machines kept in their proper condition, you should get high efficient spot welds and be able to hold a standard of spot welding.

Pressure Vessel Welding

AUGUSTINE DAVIS, JR.*

Our main articles of manufacture in which we use welding are truck tanks for gasoline and kerosene delivery and lubricating oil cans usually used in connection with the truck tanks on side racks.

In our truck tanks, on oil tight welds we use acetylene welding exclusively. It is desirable to use as light gage material as practical to stand up under heavy vibration and stress, and to be safe in wrecks. It is also necessary and desirable that these tanks be practically 100 per cent leak-proof, and remain so over long years of service, because of the obvious danger from fire, should these tanks leak. In our lubricating oil cans, the danger from fire, because of leakage practically does not exist, but it is necessary to have a non-leak can, and one that will remain so for the hardest kind of service.

In the manufacture of our truck tanks, we do not have any regular system of inspecting the welding work, except the regular air-test and soap water method used in ordinary tank shops. The tanks are tested twice, however, once before assembling, and once after. Each tank is inspected for defects in workmanship. We depend first upon the training of each welder who comes into our shop, regardless of previous experience. No new welders are permitted to work on oil tight joints until the foreman and superintendent have passed upon their fitness and reliability for this work. Secondly, constant observation is made of the work of all welders employed on oil-tight seams.

We know of no practical method of testing welds in our work other than the one mentioned above, and believe the only successful method is for a competent foreman to watch a welder in his work on comparatively unimportant welds, until the foreman is sure that this man is competent and reliable, so that we may depend upon his workmanship. The only other method we know of testing welds is by testing the tanks produced to destruction.

Figures 1, 2 and 3 show some very interesting tests run at the University of Cincinnati Testing Laboratories, and also repeated

*President, The Davis Welding and Mfg. Co.

at the Llewellyn Iron Works in Los Angeles, under the supervision of the Raymond G. Osborne Testing Laboratory.

These tests showed remarkable results in oxy-acetylene welded joints and in light gage compartment tanks where the heads of

Single test compartment, 14 gauge throughout with 300 gallon heads. Failed at 160 lbs. pressure per sq. in.

Single test compartment, 12 gauge throughout with 1000 gallon heads. Failed at 200 lbs. pressure per sq. in.

these tanks are flanged and the weld made away from the nuckel of the flange.

In regard to our 5 and 10 gallon lubricating oil cans, we recently ran a series of tests showing remarkable results. Some of the 5 gal. cans filled with water were dropped as high as 60 ft. from the top of a five-story building onto concrete, without a leak.

In conclusion, our method to date, is to run some carefully prepared tests on our products from time to time in recognized testing laboratories, under the supervision of the proper officials.

These tests are continued until the destruction of the products, either through failure of the welds, or outside of the welds.

As to the checking up of the welding operators in our shop, we have each welder stencil his shop number on each weld as he completes it. Thus any leaks or defects can be traced to the proper

Single test compartment, 12 gauge throughout with 600 gallon heads. Failed at 232 lbs. pressure per sq. in.

individual, providing a check on the welder as to his ability and reliability. This method has resulted in a very uniform and high quality of work.

We also find it desirable and quite necessary to have welders specialize on certain gages of sheet, that is, within certain limits. For instance, a man working on light gage can-work would not be safe to use without special instructions on 12 and 10 gage sheet, as his welds would most likely not penetrate all the way through. In tank work, for safety we use the butt weld and lap weld only, and never the surface to surface, edges flush, construction for oil tight joints.

We do not permit welding on piece work basis, consequently our operators are never excused for defective work on the basis of lack of time; in other words, their first qualifications must be thoroughness and workmanship.

It has been our experience, and is our belief, that more failures come through the effort to produce welds at a low cost, without having reliable, conscientious workmen than from any other cause, and we cannot see how anything will ever take the place of these qualities in welding work.

Standardization in Welding

W. SPRARAGEN*

Almost every article and book written on welding up to the last few years directly or indirectly has implied that good welding was 90 per cent dependent upon the skill of the welding operator. With the methods generally in vogue up to the last few years, this statement was probably correct, as in most cases the selection of material, design, technique and the work itself was left to the welder. Under these circumstances, it would have been more correct to state that the quality of the job was 100 per cent dependent on the operator.

Fortunately, there were a few welders who arose to minor executive positions whose experience was sufficient to make intelligent selections and rulings on these various items. However, when something new came up, this experience was not adequate and the welding either failed or the engineer was called in on the job.

The fundamental principles governing the various welding processes are not mysterious, although they are at times difficult and require careful scientific study.

In production work, where the possibilities of welding as a fabricating process appear advantageous, the particular welding application should be studied and carefully worked out by experienced engineers. The following are questions which must be answered:

1. What is the proper composition of base metal?
2. What should be the physical requirements of the base metal?
3. What kind of welding wire should be used?
4. What is the best type of joint?
5. What is the proper current or torch tip to use?
6. Should the welding be done in more than one layer?
7. What provisions must be allowed for contraction and expansion?
8. What preparation should be made of the parts to be welded?
9. What jigs and fixtures can be used to help the work?
10. What tolerances are permissible?
11. What inspections and tests should be made?
12. What should be the requirements of welders to do the particular work?

These questions can only be answered as the result of tests and trials, although experience in other similar problems can be called upon to reduce these trials and tests to a minimum. It is not fair to ask the welder to decide all of these questions, as he is not competent by training to solve them. One would not ask a riveter to answer all of these questions—there is very little that is left to *his* initiative.

When these problems are worked out, the welder is only called upon to manipulate the torch or electrode to do a particular job,

*Secretary, American Bureau of Welding.

and after a little training he can be depended upon to do the work day in and day out with less percentage of variation in quality than found in riveting, providing, of course, there is a proper inspecting and supervisory force.

Testing of Welds

The testing of welds and welded products is different for every industry. It depends on the nature of the particular problem at hand. In some cases hydrostatic pressure can be applied with a force sufficient to allow a reasonable margin over the stresses that the particular product will meet in service. Blows of a hammer, soap solution, oil penetration and reduction of air pressure are also useful for certain classes of work. In a great majority of cases tests of this sort are neither possible nor desirable. Where all of the variables, except the actual deposit of the metal, have been determined by competent engineers, the quality of the product will be known in advance. The skill of the operator can be tested and checked for the particular job at suitable intervals. Suitable inspection service should be given very careful attention.

This inspection service should include:

1. Checking whether all the requirements as to preparation before welding are fulfilled.
2. Whether suitable materials are being used.
3. Method of deposit of metal.
4. Whether the right current or size of torch tip is being used.
5. Whether the actual manipulation of the torch or electrode is satisfactory.
6. Whether the parts to be welded are clear and free from foreign matter.
7. Whether the proper penetration and fusion are being obtained.

In some cases it might be desirable to have the welder stamp his number on the job, and in still others the inspecting force might test parts of the work to destruction.

Testing the Skill of Operators

With the proper control, the quality of the given product is very little dependent upon the operator. On the other hand, he must be expert in depositing the metal for the particular job in hand. This expertness can in most cases only be tested by physical tests to destruction of tests specimens similar to the work which he is doing. Once the welder has proved himself competent to do a particular job, it rests upon the supervisory and inspecting force to see that it is done continuously.

On the other hand, great pains should be taken not to destroy the initiative of the welder. If the welder complains about conditions not being right, these should be carefully checked and not ignored, as sometimes materials which apparently have passed the purchasing department are not suitable for the work in hand.

It should also be pointed out that while some welders can do a 100 per cent job on certain work, in other instances they are entirely unfitted. For example a man that can weld thin steel in a flat position might not be able to do it in an overhead position or might not be able to weld heavy steel even in a flat position. In another instance a welder that is an expert on repair work would be entirely unsuitable, without additional training, for production work on steel.

Conclusions

It is the writer's belief that too much responsibility in the past has been placed upon the welder and that the engineer has dodged his responsibility in the matter of design, technique to be employed, and selection of materials. In many cases even the engineer can only make these decisions after numerous tests and after consulting with others. The American Bureau of Welding is ever ready to help in solving technical problems which confront the welding industry.

Railroad Shop Welding

W. H. LUDINGTON*

I am taking the liberty of modifying the topic, or rather the two topics assigned, and combining them into one, namely: "How to Insure the Performance of Good Welds," which, I take it, is the real subject or object of our discussion.

The controllable factors in such an endeavor may be listed under three general heads, first Instruction, second Supervision and third Inspection.

Let me take the last division first and say that since I am attempting to discuss the whole subject from the standpoint of railroad shop operation it may be as well to admit at the outset that, speaking in laboratory terms, very little testing or inspecting is done or can be done in connection with railroad shop or maintenance of way welding.

In railroad practice the principal use of the oxyacetylene process is for repairs, often of such a character that the broken parts are not dismantled and requiring to be put in service with the least possible delay; so there is no possibility of testing the work except by observing whether it stands up in service.

The very nature of most practical welding jobs precludes the possibility of any other test, unless the weld fails, and then the obvious course is to make a thorough metallographical study of the weld and the original metal so that the cause of failure may be determined and avoided in future work. The more progressive manufacturers of gases, apparatus and supplies maintain well equipped

*Air Reduction Sales Co.

laboratories for such studies. Many railroad laboratories have equipment and personnel for similar investigations. A check-up of this nature will only be of full value when the important welding jobs are stamped with the date and with the initials of the welder in addition to the shop record of the repairs. In this way the fault can be corrected whether it be with the operator, the welding material, or the original forging or casting.

Visual inspection of finished jobs is always desirable when the foreman is qualified to pass on the quality of the work or when the supervisor is present, as the final appearance of a weld will tell the expert welder a great deal. This phase of inspection is impossible to reduce to laboratory terms and besides is primarily a function of supervision (our second subdivison).

More searching tests of actual welding jobs might be theoretically desirable as an aid to improving welding practice, but we are confronted with a condition, not a theory, and it is a condition which there is not much hope of changing.

The situation seems to demand, then, not so much a post mortem and a coroner's jury, as good educational facilities and a police force, which brings us to the first and second sub topics of Instruction and Supervision. Instruction methods might easily be reduced to standards. In fact, this has been done repeatedly, but unless the curriculum is followed in a school or institute where both teachers' and pupils' time is entirely devoted to the work, progress is likely to be slow, and certainly the instruction will be expensive. It does seem, however, that welding is important enough to deserve more systematic schooling than most railroads find it possible to give their operators. One difficulty is the time taken from productive labor; another is the seniority system whereby a man may choose to be the welder, whether he has the necessary ability or not. (Fortunately, most men do not care to stick to welding unless they are proficient). As a result, a man becomes a welder much as he becomes a machinist or a blacksmith, but probably with less restriction. He watches the instructor and helps the other operators until he is adjudged competent to handle a job alone, and the success or failure of his welds is his only diploma. It would undoubtedly pay the railroad or any industry to require all operators to pass certain practical and theoretical tests, which would insure a sufficient degree of skill with a torch and a sufficient understanding of fundamental principles, before paying them welder's wages and entrusting important work to them. Unless the employer is willing to go to the considerable expense of giving the beginning operators a well-planned course of instruction, it does not seem practicable to attempt any periodical checking up of welders already assigned, such as the welding of coupons for laboratory test. This practice does not disclose enough concerning the welder's judgment and skill in handling practical jobs to warrant the effort. Instruction is the most important safeguard for good welding, and all the testing and

supervision in the world will not make a good welder out of an untrained or unwilling worker.

Supervision. It goes without saying that the average man's work in any art or trade requires the corrective influence of a more skilled and more experienced operator. I have chosen not merely to include under the supervisor's duties the task of watching and assisting the welders at work, but also to assume that he is a man of such recognized judgment that he has a voice in the selection of welding equipment, welding supplies and gases. He will, therefore, presumably favor the standardization of torches and regulators so as to simplify his work, he will specify only such welding supplies as can be relied upon, and he will demand high purity gases from a dependable source so as not to have important work delayed. It should be recognized that the supervisor has a big job to take care of and that he must exert himself to watch and educate not only his welders, but various other departments whose help is necessary in a successful welding program. For instance, he will need the cooperation of the stores department to insure the careful filling of requisitions for welding rods, lest the success of the weld be impaired by the issuing of the wrong rod or by the lack of supplies, and he should be in a position to obtain from his superiors the authorization for performing new welding operations which progress in the art has made possible.

Occasional changes from one type of torch to another, or the adoption of new developments makes it necessary for the supervisor to watch the performance of his operators at all times so that the correct sizes of tips, the correct pressures of oxygen and acetylene and the proper kind of adding material will be used for all welding operations. Thus it will be increasingly possible to obtain that excellence of performance which will inspire the confidence that the art of welding deserves.

Inspection of Spot and Butt Welds

By A. L. De Leeuw*

The following remarks on the inspection of welds for quality will be confined to spot welds and butt welds because those are the types with which I have had most experience. The best test I know of for a spot weld is to tear the pieces apart in tension and note carefully where the material tears. Naturally it should not tear at the weld; neither should it tear in the metal directly alongside the weld for a tear in this region is pretty sure proof that the metal adjacent to the weld has been weakened to some extent by the welding process.

Another worthwhile test is to subject a section through the weld

*Consulting engineer.

and the surrounding material to a critical examination under the microscope.

These two tests properly applied will lead to a regulation of temperature, timing, voltage and any other variable elements that will result in satisfactory production work.

When two or more spot welds are made simultaneously some test of the piece should be devised to find which of the simultaneous welds fails first. It is extremely difficult to make the welds of equal strength under these conditions and it is desirable to know which is the weak one.

In testing butt welds allowances must be made for the materials welded. When soft steel is welded to soft steel, a certain percentage of the welds should be broken, some under tension in a testing machine, others by hammer test in a vise. A welded rod held in a vise so that the weld is close to the jaws should not break at the weld under a hammer blow.

It is desirable also to secure occasional microphotographs of longitudinal cross sections through the welds and the adjacent material. Such photographs will show whether the proper amount of flash has been allowed for and also whether the other variable conditions were right.

During the development of a method of welding new pieces, all of the first lot of pieces welded should be tested to destruction. When a method begins to shape up satisfactorily it is only necessary to break 10 per cent of the pieces. Later on when the method has reached a more or less permanent stage, it will probably be sufficient to break not more than 1 per cent of the pieces. If the welding process and the operators are kept under proper control, it may be possible to reduce the number of test pieces to be broken below 1 per cent of the total produced. It has been my experience, however, that it is not wise to go beyond the 1 per cent figure.

After a method has been finally established, it often happens that the welds become progressively poorer. In the great majority of cases the fault is due to the welding electrodes not being kept clean. If the electrodes are clean, however, welded pieces will give off the same kind and amount of sparks. With dirty electrodes the sparks will shoot off at all sorts of angles and with greatly varying intensity. I have occasionally surprised a welding operator by telling him from across a room that his electrodes were dirty. Such a stunt is not at all difficult if you will observe the variation in the direction and intensity of sparks.

When dealing with a part that must equal the solid after welding, an arbitrary standard must be set; for instance, it might be required that the work be stopped when more than 0.5 per cent of the welds fail to pass a given test. No further production should be authorized until the method has been improved to the point where the test requirements can be satisfied.

When mild steel is to be welded to high speed steel or to carbon

steel, it is unwise to condemn the welding unless you are absolutely sure that the annealing has been done properly. I have found it advisable to thrust the hot steel immediately into charcoal to keep the air away from it. It is possible that some small amount of carbon may be absorbed by the hot steel, but I have never seen it proved. The piece should be transferred to the annealing furnace as quickly as possible. Of course, the ideal arrangement would be to have the welding machine so close to the annealing furnace that the finished welds would be transferred immediately from the welding machine to the furnace, but as this is seldom possible, owing to shop conditions, it is advisable to have the carbon pack to protect the hot steel in transit.

Welding in Railroad Shops

By E. WANAMAKER*

I. INSPECTION OF WELDS

1. a—Preparation for Welding:

On railroads, the preparation for welding is done in accordance with standard instructions for the principal applications and local supervision is responsible for adherence to standards, the same as any other work.

1. b—Length of Arc:

In general, whether or not the proper arc length has been maintained is best determined by visual inspection of the finished job, but, of course, can also be determined periodically during the performance of welding by observance of arc voltage, which is nominally 20 volts, for the usual run of work.

1. c—Penetration:

As in the case of arc length, visual inspection of the finished job can give some indication of penetration by the appearance of the deposit—that is, whether there are any overlappings of the added metal. Inspection for penetration may also be made periodically during the process of welding by observance of the crater from the base metal.

1. d—Fusion:

Aside from the character of the metal, from which a weld is formed, it may be said the quality of the weld is determined entirely by the thoroughness of fusion between the metals to be joined, and to some extent the character of the metal would be altered by variation in the degree of fusion, bearing in mind that thorough fusion is the principal objective for welding, and the thoroughness of fusion naturally is subject to alteration by any one or all of the variable conditions involved in welding, such for example as length of arc, cleanliness, arc current, which are conditions largely under

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control of the operator. In addition, it is also affected by the flow or penetrating quality of the wire employed and possibly the current and voltage characteristics of the welding circuit. There is, however, little to be feared from the latter feature as most of the modern equipments provide the proper current and voltage characteristics. In conclusion, proper inspection of conditions enumerated would determine the thoroughness of fusion.

1. e—Porosity:

Inspection required for this work varies with industries. On railroads, it is determined usually by hydrostatic test.

1. f—Visual Inspection of Finished Jobs:

Visual inspection of finished welds, of course, furnish some indication of the quality of the work and assuming only the surface portion of the weld indicated good welding and the remainder were poor, it, at least, indicates that the operator is competent to perform good welding and whether he does this consistently must of necessity depend either on close supervision and inspection in the application of welding or upon the operator's record.

1. g—Photographs:

On the railroad work, with which I am familiar, micro photographs are used generally in connection with tests, either for contemplated applications or to determine the cause of failure and in some instances to examine workmanship.

II. TESTING SKILL OF OPERATORS FOR SPECIFIC WORK

2. a—Handling Torch or Electrode:

Most of the inspection used for determining the quality of welds is also applicable for the testing of skill of operators. For instance, the handling of the torch or electrode could be determined by arc length, penetration, thoroughness of fusion, etc.

2. b—Selection of Current Voltage and Size of Rod:

Selection of current is usually given in standard instructions—that is, the nominal current for a given size electrode, and the size electrode for a given section or mass, in the standard instructions. There is of necessity considerable latitude in the choice of current and size of electrodes occasioned by the conditions under which the welding must be done, such as position of the work, and the thermal capacity of the parts, rate of heat conduction, etc.

2. c—Adjustment of Tips and Pressure:

In general, choice of tips are determined by the same conditions as the choice of current and electrode sizes for arc welding; the pressure varying with the make and type of torch usually furnished by the manufacturer.

2. d—Length of Arc:

As given under inspection of welds, the length of proper arc is determined by the arc potential, the degree of fusion or penetration, assuming the electrode current density of a proper value is employed.

2. e—Physical Tests to Determine Quality of Welding:

The tests for operators vary widely with the different roads. Some require no physical test if the operator fullfills qualifications with respect to the preparation of work, length of arc, penetration, choice of current, etc., where in other cases, in addition, a rough physical test is conducted by testing specimens, usually pieces of boiler plate welded together and tested to destruction by bending under the hand or steam hammer and noting the degree of bend and the structure of the weld metal, and in still other cases, samples are submitted to the laboratory for the usual tensile test.

2. f—Speed of Welding:

The consistent rate of welding is determined not only by the skill of the operator, but also by the nature and location of the part or parts to be welded, and for practical purposes can only be judged by the supervision directly in charge which is the usual procedure.

III. IN CONCLUSION

It might be well to say that at least insofar as the Rock Island Lines is concerned, we have found—after necessary and due experimentation with any new possible job that may have presented itself, or have been developed in an effort to seek a more satisfactory and more economic method—that it is first necessary for general supervisory officers in charge, with the assistance of those who have direct supervision over welding matters, to develop standard methods for preparing, performing and inspecting the entire welding job or operation, in line with standard general welding instructions and specifications. Such procedure carefully followed results in what may well be termed commercially successful welding.

Welding in Shipyards

A. G. BISSELL*

At the present time there is no commercial apparatus for testing of welded joints, although there has been developed an apparatus by which it is possible to test a butt weld with a fair degree of accuracy. This, however, is in an experimental stage, and will be some little time before it is put out. In view of these facts, it is necessary to rely entirely upon the surface inspection of the finished weld, observation of the work while being done and upon the reliability of the operator. A thoroughly competent welding supervisor can do more toward obtaining good welds than any other medium. He is continuously in contact with the operators, and by observing their work and having them make test welds he can determine the ability of the individual welder and place him

*General Engineering Dept., Westinghouse Elec. & Mfg. Co.

on such work as requires his special ability. In this way it is possible to obtain good arc welding.

In the writer's experience the following procedure was followed to produce reliable arc welders and arc welds.

1. Carefully pick the man to be trained as an arc welding operator. This man should have a fair education and be inclined to study, in order that he may keep informed on the advances made in his work. He should be a man having job pride and enthusiastic about his work. His rate of pay should be such that he has some incentive to make his work the best, and, therefore, obtain the highest rate of pay. Piece work does not encourage good welding. Speed and good welding do not go together.

2. The operator should be very carefully trained in his work. All the mystery should be removed from his work and he should be given a thorough understanding of just what happens in his weld from a mechanical and metallurgical standpoint. He should be taught how to prepare different welds or joints to get the best results. He should not be rushed in his practice work, and given plenty of time to familiarize himself with the manipulation of the arc in the various positions that will be required in welding. He should be encouraged to ask questions about his work and full and complete explanations should be given to all his questions.

3. After the operator has become proficient in depositing metal in the various positions, he should make test samples and either break them himself or have them broken in his presence so that he may see the results. It has been found that by this process the operator can see where he has done poor work and will try to correct it and prepare samples that will not fail because of lack of fusion, or poor manipulation of the arc.

4. After the operator is capable of making a reliable joint he should then be put on simple construction work under the guidance of a competent operator or supervisor and gradually advance to the more difficult work until he becomes a proficient operator. After he has become proficient on steel then he should be started at odd times in practicing on other metals as cast iron, brass and bronze and the various other phases of arc welding.

If this procedure is followed it will be possible to obtain good arc welders that can be depended upon and will produce good work, which under the direction of a capable supervisor will not require final testing by electrical, mechanical or other means.

The foregoing does not give any definite instruction as to inspecting welds but in the work at the Navy Yard only such jobs as could be tested by hydraulic pressure were tested. We usually tested an original sample to determine if the joint would stand the required strain as in the case of pipe stanchions. Samples were made and pulled before the final job was attempted. The usual run of inspection was simply knowing the welders' ability and a surface examination after the job was done.

Non-Destructive Tests of the Reliability of Arc Welds

W. L. WARNER*

Ever since the beginning of scientific investigation of natural phenomena and the application of the knowledge thus gained to the service of mankind, the engineer and scientists have been searching for check methods and tests by which to determine the reliability of mankind's handiwork without destroying that handiwork in the process of testing. In all fields of endeavor such work is going on with varying success. For many purposes tests to destruction by mechanical methods are satisfactory, but in some cases non-destructive tests are much to be desired. So it is with the welding art.

An Arc Weld and Its Appearance

An arc weld in the full sense of the name is a union of two pieces of metal by fusion, the necessary heat being generated by an electric arc which causes certain parts of the two pieces to melt and amalgamate or mix so that the two original pieces become one. Additional material may be supplied, from a metal electrode which forms one terminal of the arc, or from a separate source, which usually is a filler rod manipulated by the operator.

The outside of the deposited metal in an arc weld presents a rippled appearance, the evenness of which is dependent upon the skill of the operator and to some extent upon the welding conditions. The regularity of this rippled formation serves as a general guide to the quality of the weld, since a smooth, uniform deposit indicates a uniformity of arc conditions. However, a smooth appearance may not mean that the proper penetration or depth of fusion has been obtained. The amount of penetration is indicated by the depth of crater which may be noted wherever the arc is broken.

Inspection Test

It is quite impossible to definitely forecast the strength and quality of an arc weld on the basis of the appearance of the finished weld alone. Slag inclusions or blowholes may occur in the deposited metal and not show on the surface. One indication of improper fusion caused by too long an arc or too low welding current is the shape of the weld bead. Under these conditions the edges of the bead will appear to be folded under as if the metal were only laid on top of the work piece. This condition may be easily noticed upon close inspection.

But suppose the appearance of the deposited metal is "good," as

*Industrial Engineering Dept., General Electric Co.

a welder would say. What must we do to find out how good the weld is? If the weld has been properly made and the two pieces are firmly joined so that they form one piece, a light hammer blow on one side of the joint will cause the weld to "ring true," i.e., the sound will be closer and resonant as the sound which a solid piece of the same thickness of material would give.

Mechanical Tests

For pressure tanks or containers, pressure is usually applied up to a value several times the designed working pressure. Many defects can be easily "spotted" and corrected by this method. This test is not of sufficient severity to injure the container and even a hammer test is resorted to in some cases in order to uncover any weak spots in the weld.

Electrical Tests and Vibration Tests

During 1918 and 1919 the Welding Committee of the Emergency Fleet Corporation considered the possibilities of using electrical conductivity tests for determination of flaws and weaknesses in arc welds in general. From the minutes of the meeting of the Committee held in New York, Aug. 30, 1918, R. W. Conant of the Massachusetts Institute of Technology is quoted as follows:

"I was very doubtful of the practicability of any electrical resistance method on account of the extremely low values of the potential differences. As you may know, I have by the aid of an instrument of special design been successful in measuring much smaller differences of potential than is customary in ordinary electrical work. The commercial practicability of this method has been thoroughly demonstrated on the numerous street railways of this country and abroad. It has never been necessary, however, in this work to deal with as low resistances as will be met with in your work. Since speaking with Mr. Forbes I have given some thought to the matter and have been able to increase the sensitiveness of my method about ten times. I have made some tests with the more sensitive method on a reduced scale with remarkably gratifying results, the small cuts representing faults showing up perfectly with a very reasonable loading current and I now believe that it may be possible to determine the defective welding should it be of such magnitude as to decrease the strength of the joint 10 per cent in any one place. The chief difficulties that I have encountered with this very sensitive method come from thermo-electric currents. I have had similar difficulties before in other kinds of work and have overcome them, and in one instance caused the thermo-electric currents to be a positive advantage in the determination of the resistance."

"Of course, in new work like this, it is impossible to say before hand just what the outcome would be, but I firmly believe that the greatest chance of success lies in the direction that I have indicated."

H. C. Forbes, a member of the committee, who is referred to in the preceding quotation, suggested a sound test based upon an analysis of the wave form of a sound wave before and after passing through a portion of a weld.

"If a sound wave was produced in a welded plate by a tuning fork, the expectation would be that the amplitude of vibration of the wave would be reduced more when passing through a poor contact weld then when passing through a good contact weld."

"The sound wave would be taken from the plate at two points by phonograph sound boxes attached to metal rods and passed to the ends of a sound interference apparatus in order that only the residue of the vibration need be analyzed. If the weld gave good molecular contact, then the amplitude of vibration across it would not be materially reduced and the interference should result in comparative quiet. But if the molecular contact in the weld was poor, then the amplitude of vibration of the sound wave should be reduced in passing across the weld and in this case the greater vibration would predominate in the interference apparatus and no quiet point could be found."

"This is only a suggestion of a method easy to try but with little hope of success under laboratory conditions, and obvious obstacles which might be impossible to overcome in the field, such as extraneous noises, etc."

R. L. Sanford of the Bureau of Standards at Washington carried on an extensive series of tests in 1918 for the Emergency Fleet Welding Committee. His purpose was to discover a method of magnetically exploring the weld bead in order to discover any possible flaws in the deposited metal. The theory underlying his method may be explained by the following quotation from the minutes of the committee for Sept. 12, 1918:

"The theory can be better understood by considering first the conditions when a straight bar is magnetized between the poles of an electro-magnet. When this is done the distribution of magnetization, or magnetic flux, along the bar, if the bar is uniform, can be represented by Curve No. 1.

"The slope of this curve, or the magnetic leakage, is then represented by Curve No. 2. If the slope of this curve is plotted we get what has been called the "uniformity curve" represented by Curve No. 3. Any variation from uniformity in the bar disturbs the regular distribution of magnetic flux and consequently of the magnetic leakage. Irregularities in the leakage curve then indicate non-uniformities in the bar.

"In making the measurements on a ship plate, a portion of the plate is magnetized between the poles of a suitable electro-magnet and the magnetic leakage can be observed directly by means of a flat test coil placed against the surface of the plate and connected to a ballistic galvanometer.

"Experimental work has been done at the Bureau of Standards

with a sample of welded plate about 1/8 in. in order to point out the proper method for proceeding with the sample of ship plate which is to be sent to us.

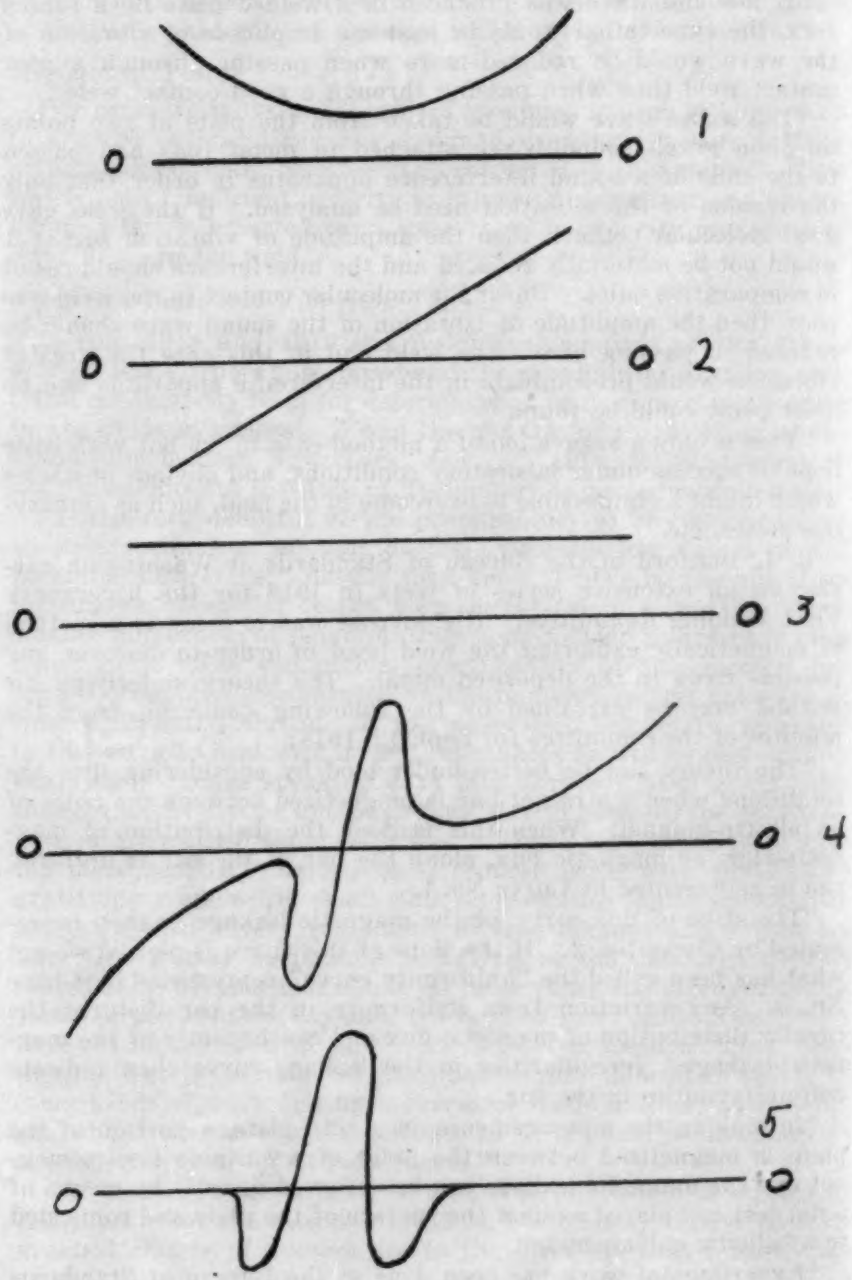

Fig. 1. Testing welds by magnetic analysis

"The first work was done by magnetizing the plate in such a way that magnetic lines of force pass transversely across the weld. The curve of magnetic leakage that has been obtained is approximately of the form indicated in Curve No. 4. The uniformity curve taken from these observations is nearly of the form indicated in Curve No. 5, showing that there are magnetic soft spots at each side of the weld and a magnetic hard spot at the center. This method of examination does not seem to be promising, due to the fact that even a perfect weld constitutes an inhomogeneity in the plate and variations in the quality of the weld would be shown as variations in the magnitude of this inhomogeneity."

"Experiments are now in progress with the electro-magnet placed so as that the magnetic lines of force travel longitudinally along the length of the weld. This seems to be a more promising method of attack."

In the Sept. 26, 1918, minutes of the Committee is given a further report from R. W. Conant of the Massachusetts Institute of Technology as follows:

"Mr. Ewertz and Mr. Cozad of the Bethlehem Shipbuilding Corporation have cooperated in this investigation and have prepared for us a test plate which consists of two pieces of ½-in. steel plate each 2 ft. sq. welded together on one edge. The character of the 2-ft. weld was varied throughout its length to include good and bad sections. We were not informed as to the locations of the good and bad parts and the surface of the weld was covered over throughout its length with welded metal to appear of uniform character."

"Mr. Conant has been working on this plate in our laboratory since Aug. 29, 1918. Early in the month of September it was agreed in a conference between Mr. Forbes, Mr. Conant and myself that it would be desirable to investigate first the application of Mr. Conant's method to the location of concealed saw cuts made in the test plate to imitate defective welds. Two saw cuts were made along the central axis of one member of the test plate. These saw cuts, each about 4 in. in length, were respectively ¼ in. and ⅜ in. deep to represent joints of 50 per cent and 25 per cent efficiency. Mr. Conant has been applying his method to the location of these saw cuts and on Sept. 21, 1918, Mr. Conant informed Mr. Forbes and myself that he was ready to locate such concealed saw cuts in a steel plate."

"Two saw cuts were then made along the central axis of the other member of the test plate; one 4½ in. in length and ⅜ in. deep to represent a joint of 25 per cent efficiency and the other 4⅜ in. in length and ¼ in. deep to represent a joint of 50 per cent efficiency. The plate was then turned over and with the exception of a chalk line indicating the axis along which the saw cuts had been made there was nothing to indicate their location. Mr. Conant, on Sept. 23, 1918, after working 29 minutes, indicated by chalk marks the

results of his investigation as follows: One saw cut was located at a point beginning 3½ in. from the edge of the plate, extending 3¾ in. along the axis and marked "Bad—rejected." There was actually a saw cut in the plate at this point beginning 3¼ in. from the edge, extending a distance of 4½ in. along the axis and ⅜ in. deep, representing a joint of 25 per cent efficiency. The other saw cut was located by Mr. Conant at a distance of 19⅝ in. from the edge of the plate, extending 1½ in. along the axis and marked "Very slight defect." There was actually a saw cut in this region beginning 17⅜ in. from the edge of the plate, extending 4⅜ in. along the axis and ¼ in. deep, representing a joint of 50 per cent efficiency.

"It should be noted interpreting these results that the saw cuts was 3/32 in. wide and being made with a milling cutter the saw cut did not attain its actual depth abruptly, but sloped from the surface of the plate to the bottom of the saw cut over a distance of about ¾ in. It should be stated then that Mr. Conant located the joint of 25 per cent efficiency exactly and located another defect approximately but without recognizing its low efficiency."

The work described in the foregoing report from Mr. Conant was a preliminary study of the possibilities of the resistance method of determining efficiencies of welded joints. In this work Mr. Conant used ordinary flat plates with slots cut into the plate at various points by a milling cutter. The results of his later work on arc welded joints are given in the following report dated Sept. 27, 1918:

"The following is a report of an investigation regarding the relationship between the relative electric conductivity and the efficiency of an electric welded joint. Twelve welded joints were prepared for this purpose by the Bethlehem Shipbuilding Corporation. In each case two steel bars each 2$^{3}/_{16}$ in. by ½ in. by 7 in. were welded together on the 2$^{3}/_{16}$ by ½ in. surface. The electric conductivity of the welded joint was compared with that of the steel bar by comparing the resistance between two joints bridging the welded joint and two other points on the steel bar, the distance between the two points in each case being 2 in. The welded bars were then pulled apart in a testing machine to determine their respective ultimate strengths. The results of these measurements are given below in tabulated form.

Mr. Conant summarizes these test results as follows:

"The relative conductivities and the efficiencies are accurate while the relative sections are only approximate. The results indicate that measurements of the conductivity of a welded joint, under laboratory conditions impossible to duplicate in a shipyard and with the plate divided into small parts so that the conductivity of localized portions of the weld may be measured with high accuracy, may not indicate the efficiency of the joint closer than 20 per cent and that a relative conductivity of 110 may indicate an

TABLE I

SPECIMEN DATA

Relative conductivity versus efficiency of electric welded joints.

Specimen Number	Section of Weld Section of Bar	Cond. of Weld Cond. of Bar	Efficiency of Weld
1	121	110	262
2	135	118	80
3*	100	102 (113)	62
4	129	110	74
5	128	110	82
6*	103	104 (109)	60
7†	134	114	Above 100
8	130	112	87
9†	150	112	Above 100
10†	102	98 (118)	82
11†	147	117	Above 100
12†	156	121	Above 100

* Surface of weld planed off to surface of bar.
† Specimen broke outside of weld.
() Relative conductivity before planing.

Conditions under which welds were made.

Specimen	Experience of Welder	Voltage	Current
1	Less than one month	65	110
2	Less than one month	65	110
3	Less than one month	65	80
4	Less than one month	65	80
5	Two months	65	75
6	Two months	65	75
7	Nine months	62–66*	110–130*
8	Nine months	62–66*	110–130*
9	Long experience	35	125 to 140
10	Long experience	35	125 to 140
11	Long experience	35	125 to 140
12	Long experience	35	125 to 140

* Two layer welds; first layer, 62 volts, 110 amperes, and second layer, 66 volts, 130 amperes.

In specimens 1 to 8, Roebling's standard 5/32" wire was used and in specimens 9 to 12, Wilson Welder and Metals Co. welding wire; Grade 6 for specimens marked A and Grade 9 for specimens marked B.

An examination of these data reveals the following results in classified form:

Specimen Numbers	Relative Section	Relative Conductivity	Efficiency Differs by
1— 4— 5	Approx. same	Same	20%
3— 6—10	Approx. same	Approx. same	20%
7— 8	Approx. same	Approx. same	More than 13%
2—11—12	Differ by 21%	Approx. same	More than 20%
8— 9	Differ by 20%	Same	More than 13%

efficiency as low as 62 per cent, while a relative conductivity of 112 may indicate an efficiency greater than 100 per cent."

From the foregoing discussion it may be easily seen that an electrical test on welded joints is neither practicable nor reliable under ordinary shop conditions. Even under laboratory conditions the methods outlined are difficult to apply.

The question of reliability of arc welds is a broad one and the subject of every welding discussion. One of the great arguments

put up against welding by those opposed is the supposed impossibility of making a satisfactory conclusive examination of the finished weld. This sounds rather convincing, but is it a sound conclusion? John B. Taylor, Consulting Engineer of the General Electric Company at Schenectady outlines this situation very satisfactorily in a letter to the committee dated Sept. 13, 1918. This letter is quoted here:

"Since the passing of the stone age, it has been desirable to know of the presence of foreign material or flaws, whether welded up by forge and hammer or by any other means. In general, the assurance of a proper weld and the placing of reliance on a structure seems to come down to confidence in the blacksmith (or the more recent holder of the electrode) based on the experience which he and his instructors have gained by examination of the pieces which have failed in service or by the breaking, cutting and otherwise examining and testing specimens sacrificed for this purpose.

"I gather that what you are looking for is the proving of workmanship and material in the course of regular quantity production. While a perfect weld doubtless differs from a bad one in the several physical properties, such as: mechanical (including acoustical), thermal, optical (transparency to x-rays), electrical and magnetic. There appears small prospect for determining the presence of flaws or lack of homogeneity without bringing the weld itself and the adjacent material to a smooth, plain surface, which, with the additional time and expense required for the x-ray exposures or careful determination of other physical properties, would more than use up the savings incident to the introduction of electric welding. To a certain extent the effect of flaws on acoustical properties are determined by the simple method of tapping with a hammer, either by the welder himself or by an inspector, but this test by sound is not new and is still rather crude.

"My own feeling is that when the science and art of electric welding have progressed further, there will be no more call for a special test on each inch of weld than we have now for examining by high technical methods each brick and surrounding mortar in a building. From experience we know what stresses can safely be placed on a brick wall laid up by an experienced mason and we do not trust other than experienced masons to lay our bricks.

"I believe better progress will be made in advancing the art of electric welding by taking and breaking many test specimens and subjecting many of these and other test specimens to chemical and microscopic analysis. The technic of such tests, examinations and analyses are already well developed apart from the advent of electric welding. Beyond this there seems to be an open field for learning much of the exact behavior electrically, optically, thermally, mechanically and chemically within the fraction of an inch at the electrode and weld itself. Doubtless a better understanding of the

phenomena incident to the electric arc and the deposition of the material would indicate improved materials and methods or the more important precautions in the handling needed to insure reliable welds."

Too much emphasis cannot be laid on Mr. Taylor's remarks as the surest way to secure dependable welds is to use dependable and competent operators for welding work. A check up once in a while and an experienced supervisor are necessary to insure a good standard grade of welding. The sooner the welders and the profession realize this the sooner the conscientious objectors and others will be compelled to keep quiet.

Inspection of Metallic Electrode Arc Welds*

O. H. ESCHHOLZ†

The lack of a satisfactory method for determining the character of welded joints has been responsible, more than any other factor, for the hesitancy encountered among the engineering profession toward the extensive adoption of arc welding. To overcome this prejudicial attitude, it is eminently desirable to shape our rapidly accumulating knowledge of the operation into an acceptable method of inspection.

Practically all manufactured apparatus is accepted on the basis of compliance with a process specification rigidly enforced, in conjunction with the successful reaction to certain tests applied to the finished product. While it is commonly known that riveting seriously impairs the strength of the joined plates, yet with a proper layout and intelligent inspection, the completed structure possesses certain definite characteristics which do not require further verification. The inspector of a finished concrete structure is practically helpless. It is obvious that the weakest sort of construction may be concealed by a sound surface. With a rigid supervision of the process, however, the physical properties of the completed structure can be reliably gaged to the extent that its use is justified even in ship construction. In view of this, it is comforting to realize that electric arc welding is susceptible to even better control than either of these structural operations.

How to Determine the Character of the Weld

The factors which determine the physical characteristics of metallic electrode arc welds are: (1) fusion, (2) slag content, (3) porosity and (4) crystal structure.

*Extracts from article appearing in Railway Mechanical Engineer, July, 1918.
†Formerly connected with the Westinghouse Electric & Mfg. Co.

Some of the more important methods that have been used or suggested as a means for indicating these characteristics are:

1. Visual examination of weld to determine
   (a) Surface finish as an index to workmanship,
   (b) Length of deposits, indicating frequency of breaking arc and, therefore, ability to control arc,
   (c) Uniformity of deposit as an indication of the faithfulness with which filler metal is placed in position,
   (d) Fusion of deposited metal to bottom of weld scarf as shown by appearance of under side of joint,
   (e) Predominance of surface porosity and slag.
2. Chipping edges of deposited layers with cold chisel or calking tool to determine relative adhesion of deposit.
3. Penetration tests indicating linked unfused zones, slag pockets and porosity by
   (a) X-ray penetration,
   (b) Rate of gas penetration,
   (c) Rate of liquid penetration.
4. Electrical tests showing variations caused by incomplete fusion, slag inclusions and porosity:
   (a) Electrical conductivity,
   (b) Magnetic induction.

The most complete use of these tests would involve their application to each layer of deposited metal as well as to the finished weld. Excepting in rare instances this, however, would not be required by commercial practice in which a prescribed welding process is followed.

Of the above methods the visual examination is of more value than is commonly admitted. In conjunction with it, the chipping and calking tests are of particular usefulness. As, however, only a very poor joint will respond to the latter tests, they serve to indicate gross neglect by the operator of cardinal welding principles.

The penetration tests offer the most reliable indication of the soundness of a weld. Obviously, the presence of unfused oxide surfaces, slag deposits and blow holes will offer a varying degree of penetration. The use of X-rays gives excellent results in the test of small samples, but due to the nature of the apparatus, time required and difficulty of manipulating and interpreting results, it can hardly be considered at the present time applicable to large scale production.

The rate of leakage of hydrogen or air through a joint from pressure above atmospheric to atmospheric, or from atmospheric to partial vacuum can be readily determined. However, the equipment required would be quite cumbersome and the slight advantage over liquid penetration in time reduction is not of sufficient merit to warrant consideration for most welds.

Of the various liquids that may be applied, kerosene has marked advantages due to its availability, low viscosity and property of

wetting the iron surface. Because of the latter characteristics, kerosene sprayed on a weld surface is rapidly drawn into any capillaries produced by incomplete fusion between deposited metal and weld scarf or between succeeding deposits, slag inclusions, gas pockets, etc., penetrating through the weld and showing the existence of an unsatisfactory structure by a stain on the emerging side. On dissolving suitable oil soluble dyes in kerosene, the penetrating liquid will produce a bright red stain. This test is so useful that it has shown the presence of faults that could not be detected with hydraulic pressure or other methods. A sequence of imperfect structures linked through the weld, which presents the greatest hazard in welded joints, will be immediately located by the kerosene penetration. However, it should be borne in mind that this method is not applicable to the detection of isolated slag or gas pockets, nor small disconnected unfused areas. Nevertheless, it has been shown by numerous tests that it is quite possible for a weld to contain a considerable amount of distributed small imperfections without affecting appreciably its characteristics.

If the kerosene test betrays a bad fault, it is advisable to burn out the metal with a carbon arc before rewelding under proper supervision. Large quantities of kerosene are preferably removed by means of sand blast, steam, gasoline, pyrene, etc. No difficulty, however, has been encountered on welding over a thin film of the liquid.

Electrical test methods for determining the homogeneity of welds are still in the evolutionary stage. Such obvious difficulties as elimination of the effect of contact differences influence of neighboring paths and fields, the lack of practicable, portable instruments of sufficient sensitivity for the detection of slight variations in conductivity or magnetic field intensity are yet to be overcome before their employment is feasible.

No simple tests are available, excepting those which involve subjecting the metal to excessive stresses, for determining the crystal structure. Control of this phase must be determined by the experience obtained from following a prescribed process.

While, therefore, the inspector of metallic electrode arc welds may consider that through the proper use of visual, chipping and penetrating tests a more definite appraisal of the finished joint may be secured than is possible in the visual inspection of either riveting or concrete construction, the welding operation may be still further safeguarded by requiring rigid adherence to a specified process.

Good Results Are Certain if Procedure Is Followed

Haphazard welding can no more produce an acceptable product than hit-or-miss weaving will make a marketable cloth. It is logical that the steps in every manufacturing operation should be controlled to obtain consistently good results. Unfortunately, most welders consider themselves pioneers in an unknown art that requires the exercise of a peculiar temperament for its successful

evolution. As a result, welding operators, too numerous to mention, enshroud themselves in the hallowed glow of an expert and encompass their work with a mysterious camouflage bewildering to the untutored. Sometimes, through a series of fortunate coincidences, these "experts" succeed in obtaining a good weld, but more often their "success" is attributable to the friction between slightly fused, plastered deposits.

Welding in the Oil Industry

F. C. FYKE*

Probably the one thing that is retarding the art of fusion welding more than any one other is the lack of, or inability to apply, any practical test to the finished work that will be indicative of a sound weld and enable one to pick out bad welds after once made. While the surface appearance, if closely studied and checked with the test results, does give an indication of the quality, in a single bead weld, this check is of very little value in the case of heavier welds. X-Ray examinations of welds have been made, with a view of arriving at some means of detecting defective welds, but the development that has been made to date shows that there is very little practical application of this method. The most promising method, in the testing of welds, is the magnetic process. However, due to the sensitiveness of this apparatus, it is doubtful whether this method will be practical in shops where heavy work is being carried on and vibrations are excessive.

As already mentioned, the lack of suitable means for the practical testing of welds, so as to indicate or show the engineer when he has a sound weld, results in the much used saying, which we are all familiar with, that is, that the weld is no better than the operator. This alone is causing the engineer to hesitate in advocating a broader application of welding, particularly in high temperature and pressure work, in spite of the rapid strides made by the art during the last few years. This problem is one that should be given attention by this Society and is of such importance as to warrant extensive research work being made. The question of design can be easily taken care of once we have means of knowing what we have to design with.

The human element, upon which depends to a large extent, the quality of the weld, must be carefully studied if the best results are to be obtained. The mere hiring of a man who says he is a welder should mean very little in the welding shop until he has demonstrated to the satisfaction of his foreman that he is capable and can be trusted on any class of work. Gas welders and electric welders are each in a class of their own and to obtain the best results they should not be interchanged on both classes of work.

*Engineer, Testing Department, Standard Oil Co. of New Jersey.
Extracted from an article on the above subject in the January, 1925, issue of Journal, A. W. S.

Shop conditions may be such, however, that, while desirable, this practice cannot be always carried out.

Men selected for training as welders should possess certain qualifications which should prove valuable assets to them in helping them become successful welders. They should be enthusiastic about the subject and have had enough mechanical experience such as to give them a fair knowledge of the physical working of metals. Neat, conscientious work, with the thought of quantity, but never at the sacrifice of quality, should give unquestionable results, if properly handled in training.

Too little time is given to the training of new welders. The training period throughout the different industrial shops ranges from one week to six months. This varies with the different shops throughout the country and is governed somewhat by the pressure of work under way.

Welders, as compared with boilermakers, machinists, and other mechanical labor, should be on a standard equal to the highest. As has already been stated, there is no other trade in which the results depend so largely upon the individual as in welding. The welder's responsibilities are affected by a wide range of conditions, and the art should receive a high standard of recognition when compared with the other mechanical trades. This alone will be manifested in the results that will be obtained through more conscientious work.

It must be assumed that the foreman in charge is capable to the extent of affording proper supervision of all work. He must have a thorough knowledge of the material to be welded if his results are to be satisfactory. The success of any weld depends largely upon whether the material has been properly prepared and whether the most adaptable process, for the service, has been employed. For this reason, the foreman should be fully acquainted with the working conditions to which the weld is to be subjected and the suitability of the different types of welding and design of welds for these conditions. The question of whether studding, preheating, and the many other points to be taken into consideration in the proper preparation of a weld, has been intelligently considered, is of primary importance.

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*Complaint and Investigating Dept., York Manufacturing Co.

disclose any porosity, or points of incomplete fusion. Tightness and strength are paramount and appearance is secondary. For this reason we do not put much importance on visual inspections.

Testing the Skill of the Operator

A new operator is required to make a sample piece of work and his ability to handle and adjust the apparatus is observed. We have no specific tests which must be met. If the quality of his sample work is satisfactory he is started on the less important work. Since all pieces are given strict tests any inefficiency is uncovered. As a new man proves himself capable he is given more important work. Only the experienced men are allowed to weld the important pieces. We have no specific tests for the operators.

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Fundamentals of Welding Gas, Arc and Thermit. James W. Owens. $10.00.
Arc Welding Handbook. C. J. Holslag. $2.00.
Oxy-Acetylene Welding and Cutting. P. F. Willis. $1.50.
Automobile Welding with the Oxy-Acetylene Flame. M. Keith Dunham. $1.50.
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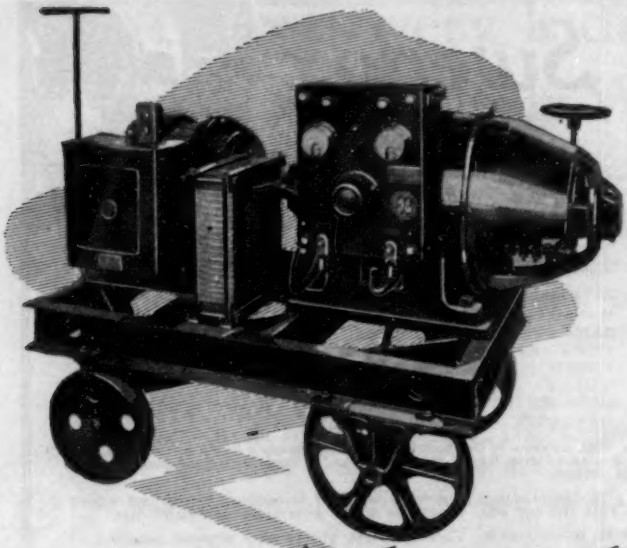

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The WD-12 Arc Welder

—can be furnished for any commercial voltage, phase or frequency.

—delivers 200 amperes continuously and 300 amperes for short periods.

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—reactor automatically steadies arc.

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—supplies power to G-E Automatic Arc Welder for continuous welding.

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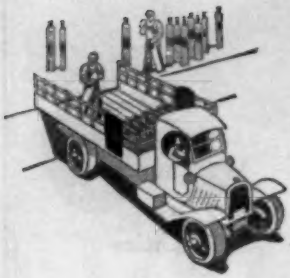

YOUR REQUEST for Linde Service will not always bring you a man. Problems similar to yours may have been solved so frequently by Linde that the solutions have been compiled into a book or covered in a magazine article.

These books and magazines, which are a part of Linde Process Service, will not answer all of your questions. But they will answer many of them.

Linde Process Service will not do your work for you. Yet it may be necessary for a Linde Service operator to use a blowpipe to demonstrate the correct practice.

Linde Process Service will not train your operators. But it will help you to teach them and keep them informed on the latest practices.

Linde Process Service will not run your shop. But it will help you do your welding and cutting in accordance with the best shop methods.

Linde Process Service will not do your engineering. But Linde engineers can be of assistance to your own engineering department on all phases of welding and cutting.

Finally, Linde Process Service will not be perfect. But it is the best answer today to problems which arise when the oxy-acetylene process is used or contemplated. Furthermore, successful service in each specific case makes Linde Process Service better and more helpful to all Linde customers.

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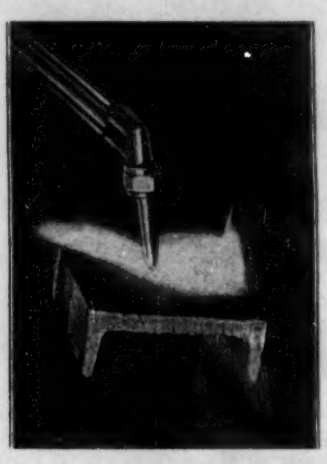

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